P.I.N. X051.59

BRIDGE DECK EVALUATION REPORT

A. Structure Identification

Description:	Grand Central Parkway over Winchester Blvd and Cross Island Parkway and Ramp “H” over Cross Island Parkway
BIN:	1065149 and 106514A
GCP Reference Marker:	1120 to 1124
County:	Queens
City of:	New York
Region:	11
Feature Carried:	Grand Central Parkway and GCP Ramp “H”
Feature Crossed:	Cross Island Parkway Winchester Blvd

B. Introduction

History of Bridge

Structures are located in the City of Queens, Queens County, NY. BIN 106514-9 carries the Grand Central Parkway over the Cross Island Parkway and Winchester Blvd, while BIN 106514-A carried ramp H over the Cross Island ParkwayBoth structures were built in 1972 as part of Contract. F.A.G.C.P 70-1. The mainline structure is 1,907 feet in length and the ramp is 158 feet long. The mainline consists of 15 spans, while the ramp is a single span. The superstructure for both structures is comprised of steel multi-girders with an 8 inch monolithic reinforced concrete deck. There is no asphalt overlay. Span lengths vary from 82 feet to 162 feet. The out to out width of the mainline averages 127.5 feet. No major rehabilitation has been performed, but the mainline deck has been subject to extensive patching and repairs over its lifetime.

This structure is being evaluated for a deck rehabilitation or deck replacement project.

Structural Ratings (2020 Biennial Inspection)

Mainline (1065149)	
NYSDOT Gen Rec:	5
NBI Deck Condition:	4
NBI Superstructure:	7
NBI Substructure:	5

Ramp “H” (106514A)	
NYSDOT Gen Rec:	5
NBI Deck Condition:	6
NBI Superstructure:	7
NBI Substructure:	5

Highway Classification

Mainline (1065149)	
Functional Classification:	Urban Principal Arterial Expressway
National Highway System:	Yes

Ramp “H” (106514A)	
Functional Classification:	Semi-Direct Connector Ramp
National Highway System:	No

C. Deck Inspection Findings

1. In-Depth Deck Inspection Report
2. Non-Destructive Testing Report

IN-DEPTH INSPECTION REPORT

P.I.N. X051.59

ELEMENT SPECIFIC BRIDGE WORK

B.I.N. 1-06514-9 & 1-06514-A

TEAM LEADER CHRISTOPHER DORMAN — 099456 (NYSPE LICENSE #)

ASSISTANT TEAM LEADER IAN PETERSEN

FEATURE CARRIED Grand Central Parkway

FEATURE CROSSED Cross Island Parkway

DATE FIELD WORK BEGAN 7/19/21

DATE FIELD WORK COMPLETED 9/21/21

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DISCLAIMER

This inspection report is based on data and conditions that were generally applicable as of September 2021 and the conclusions and recommendations herein are therefore applicable only to that timeframe. This report should not be used as the sole basis for the preparation of rehabilitation or repair plans, construction or remedial action, or as a basis for major capital decisions.

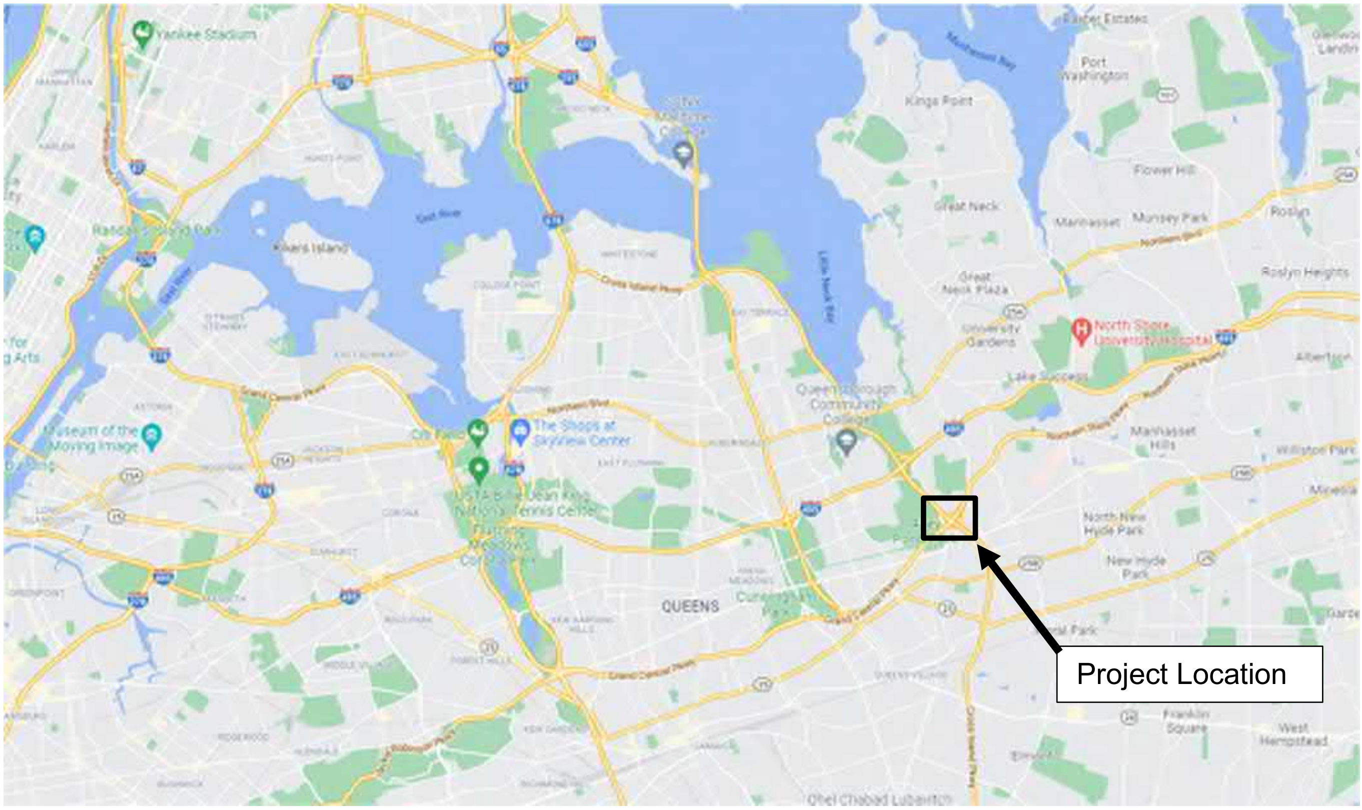
SCOPE OF WORK

An in-depth inspection has been performed on the following structures: BIN 1-06514-9 & 1-06514-A.

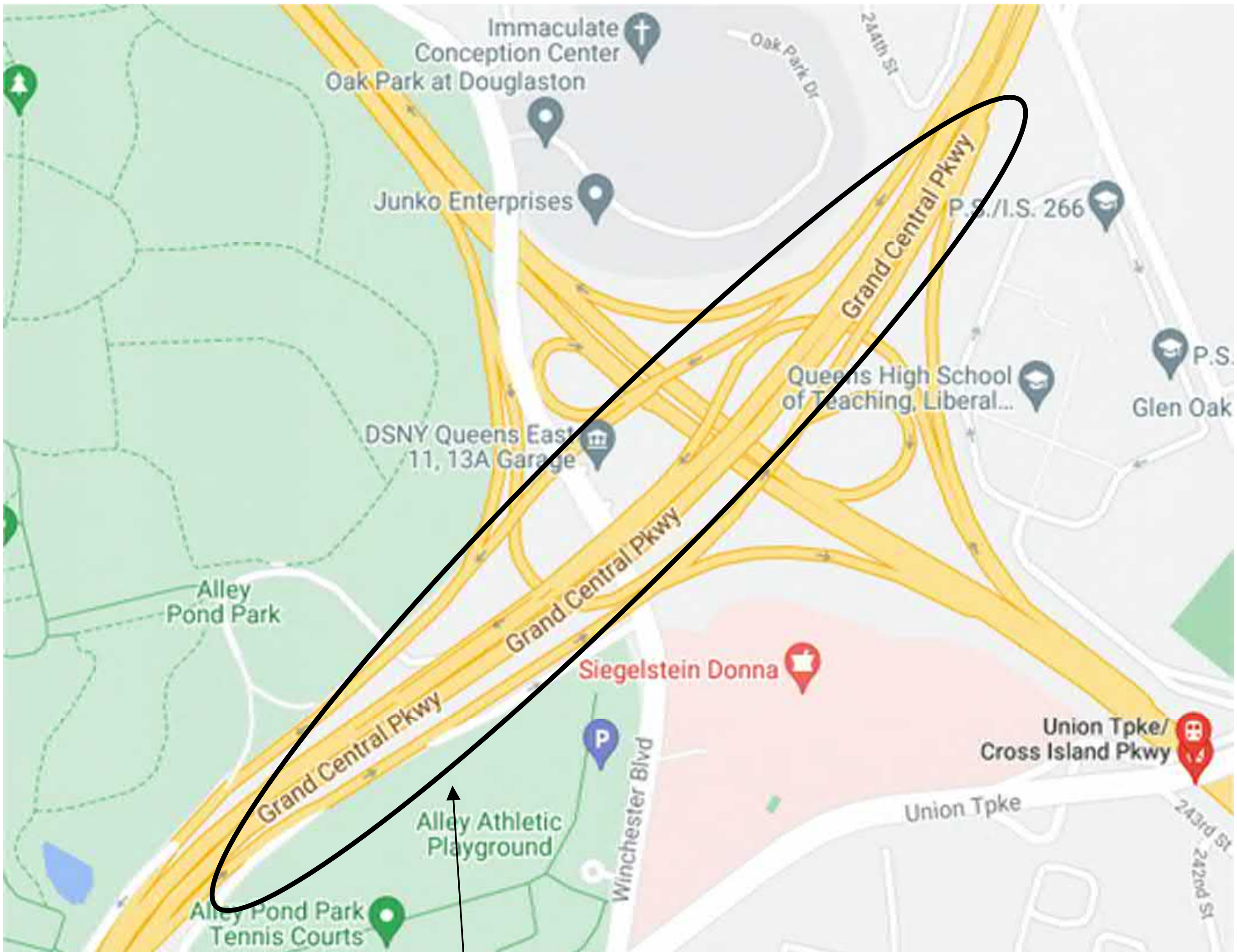
The intent of these inspections is to perform a high-quality study detailing the condition of each bridge and to document the findings for easy reference.

Deck/ approach concrete coring was performed. The coring consisted of:
16 cores - deck
6 cores – Approach Slab

PROJECT LOCATION MAP

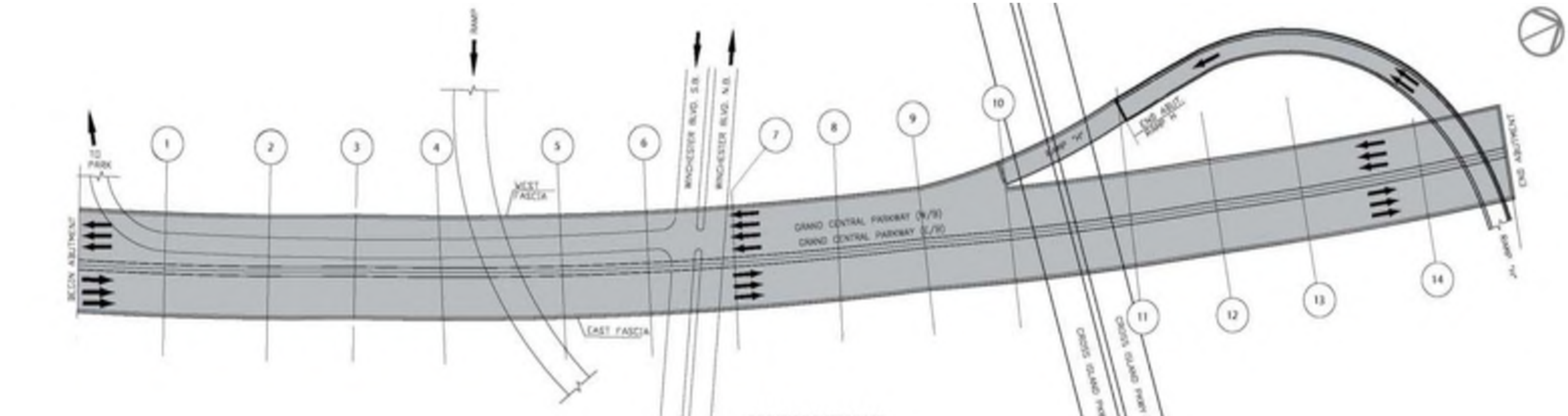


BRIDGE SITE

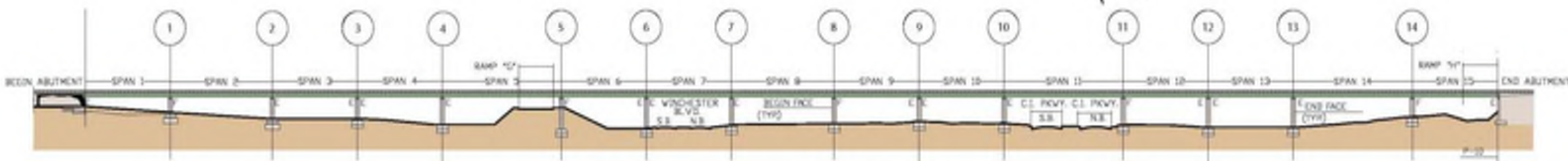


BIN: 1-06514-9 & 1-06514-A
Grand Central Parkway
Over Cross Island Parkway

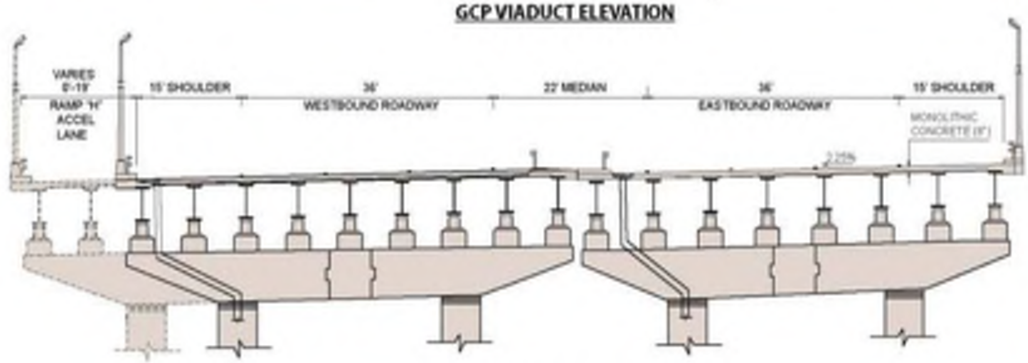
EXISTING BRIDGE SECTION



GCP VIADUCT PLAN



GCP VIADUCT ELEVATION



TYPICAL GCP VIADUCT SECTION

(LOOKING NORTH)

For Reference Only

STRUCTURE IDENTIFICATION

a. Bridge Identification Number (BIN): 1-06514-9 & 1-06514-A
b. Reference Marker: NA
c. Region: NYSDOT Region 11
d. County: Queens
e. Town: Queens
f. Feature Carried: Grand Central Parkway
g. Feature Crossed: Cross Island Parkway

INTRODUCTION

The Grand Central Parkway bridge constructed in 1972, carries vehicles over the Cross Island Parkway & Winchester Blvd. in Queens County, New York. The bridge is a 15 span, steel multi-girder, with a composite concrete deck. The span lengths vary across the bridge. There are expansion joints at Piers 3, 6, 9 and 12. The Begin (West) abutment has moveable rocker bearings and the end (East) abutment has moveable rocker bearings. The girders for all spans are built up sections consisting of a top and bottom flange that has varying thickness throughout the bridge. Spacing remains consistent at 7'-2" along the North pier and 8'-2" along the South pier. The girders in cross-section varied from 17 Girders in spans 1-3 and 10-15, 18 Girders in spans 4 - 6, 19 Girders in spans 7 – 9, and an additional 5 Girder in span 10 for Ramp H. An overall out-to-out bridge width which varies from 119'-4" to 150'-9". The bridge carries 1 shoulder and 3 lanes of Eastbound traffic, 1 shoulder and 3 lanes of Westbound traffic. Ramp H is 33'-0" wide and connects to the Westbound side of the bridge at Pier 10.

An in-depth bridge condition inspection of the underside of deck was performed on various dates from July 19, 2021 to September 21, 2021 with a top of deck inspection being performed from August 28, 2021 to September 10, 2021 by engineers from Michael Baker Engineering, Inc. The bridge was accessed from the ground and bucket truck with work zone traffic control on the Northbound and Southbound Cross Island Parkway and the Northbound and Southbound Douglaston Parkway provided by BER. All substructure, superstructure and approach elements were inspected, photographed and evaluated for condition and function. A complete description of the inspection findings is included in the Condition Evaluation section of this report.

INSPECTION PERSONNEL

Qualifications (experience, certifications, and training) and responsibilities of bridge inspectors shall be in accordance with Section 165.5. (a)(1) of the Uniform Code of Bridge Inspection and the NBIS.

DATE OF INSPECTION

Date	Time	Inspection Description
7/19/2021	8:00 AM – 4:00PM	From West Abutment to Pier One
7/20/2021	8:00 AM – 4:00PM	From Span 2 to Pier 4
7/21/2021	8:00 AM – 4:00PM	From Pier 3 to 6
7/22/2021	8:00 AM – 4:00PM	From Pier 6 to 8
7/23/2021	8:00 AM – 4:00PM	From Span 9 to Pier 10
7/26/2021	8:00 AM – 4:00PM	From Span 10 to Pier 11
8/28/2021	10:00 PM – 5:00 AM	Top of deck
8/30/2021	10:00 PM – 5:00 AM	Top of deck
9/2/2021	10:00 PM – 5:00 AM	Top of deck
9/7/2021	10:00 PM – 5:00 AM	Top of deck
9/9/2021	10:00 PM – 5:00 AM	Top of deck
9/10/2021	10:00 PM – 5:00 AM	Top of deck
9/14/2021	10:00 PM – 5:00 AM	From Pier 11 to 12
9/15/2021	10:00 PM – 5:00 AM	From Pier 10 to Span 11
9/16/2021	10:00 PM – 5:00 AM	From Pier 6 to 7
9/21/2021	10:00 PM – 5:00 AM	From East Abutment to Span 12

IN-DEPTH CONDITION DOCUMENTATION

<u>Bearings</u>: The bearings at the West (Begin) abutment and piers 2, 3, 6, 7, 9, 10, 11, 12, 13 and the East (End) abutment are rocker bearings. The bearings at Pier 1, 5, 8 and 14 are fixed bearings. Each bearing is anchored to its pedestal with two, 1" diameter anchor bolts. Along the Begin abutment girder G1 bearing exhibits heavy pack rust which has frozen the bearing in place, along with deterioration of the anchor bolt nut. At pier 3 girder G15 bearing exhibits paint loss and pack rust. At pier 6, span 6 side, bearings vary from upright to tilting in expansion mode from 1 up to 6 degrees, on span 7 side bearings 5-7 show pack rust under curved edge of rocker. At pier 9 span 10 side, bearing G2 shows tilting in expansion mode about 4 degrees, bearing G14 exhibits heavy pack rust and paint chipping. At pier 9 bearing G1 shows tilting in expansion mode about 4 degrees, and heavy pack rust and paint chipping. At pier 10 Ramp H side bearings under G1 exhibit heavy pack rust and loss of paint. Pier 12 end bearings exhibit pack rust under curved plate. End (East) abutment exhibits loss of paint on bearings under G1, G10, G11, G12 and G17. (see photos 1 – 4 & 54).

<u>Abutments</u>: Both the west and east abutments have similar geometry and solid stem with footing founded on earth with backwall. There are relatively short, cantilevered wingwalls, constructed parallel to the roadway in a U-wall configuration and constructed monolithic with the abutment stem & backwall. There are 43" x 21" pedestals under each of the 17 girders, that are supported by the stem. The East and West abutments are not skewed. The backwall height for the East and West abutment varies from 4'-4" to 6'-4". The overall length of the East and West abutment is 123'. The stem height for the West abutment varies from 10'-2" to 12'-2" and 2'-0" to 22'-0" for the East abutment. The stem walls run the full length of the abutments.

Both abutments are still in good condition and fully functional. The backwall of the West Abutment (Begin) exhibits approximately 3" wide by full height crack in the North section behind G1, The area of the crack is hollow sounding but the concrete is stable. The East Abutment (End) exhibits approximately a 6 SF spall behind G1. (see photos 5, 6).

Ramp H abutment is in good condition and fully functional. The South face exhibits a 4 SF spall with cracking, the North face exhibits a 4 SF spall with exposed rebar. The North most electrical panel on the Ramp H abutment was partially open and unlocked. (see photos 53).

<u>Wingwalls</u>: The wingwalls are about 16 ft. high at the West (Begin) abutment and vary from 6' – 26' high at the East abutment- and run approximately parallel to the roadway. They extend approximately 45'-0" from the abutments in both quadrants for the West abutment and 15' on the North side and 40' on the South side for the East abutment. The wingwalls are completely solid and in good condition.

<u>Approach Embankment / Drainage</u>: The approach roadway to the bridge is constructed on a 17 ft. fill embankment. Both the East and the West embankments are well-vegetated and appear stable. There is no evidence of excessive settlement of the embankment or roadway. The roadways appear to drain expediently, and no areas of standing water or localized low areas were observed on the bridge or along either approaches.

Fourteen drainage inlets exist along the middle of the bridge. All fourteen are located at each pier along the bridge. All structures are in good condition and are free to drain except for the drain at pier 3 bay 11 which exhibits a large 6" wide hole in the spout allowing water to spray onto pier and pier 9 bay 2 where the connection has deteriorated away. (see photos 7, 8).

<u>Approach Pavement / Wearing Surface:</u> The concrete approach pavement is generally in good condition. Along the West abutment (Begin) joint exhibits several spalls which have been repaired previously but have closed the joint. There is very shallow wheel path rutting and the ride quality over the roadway is smooth.

<u>Joints:</u> The sealant on both the West and East abutment is beginning to dry out and deteriorate and has accumulated debris. The finger expansion joints at pier 3, 6, 9 and 12 all have dirt and debris filled in the edges which inhibit the proper function of the joint. There is also evidence of water leakage on the piers and end diaphragms below the finger joints. (see photos 47, 48).

<u>Vertical Clearance:</u> Vertical clearance has not changed since the previous inspection report. **See attached vertical clearance in Appendix A.**

<u>Railings:</u> The railings are in good condition with no meaningful corrosion. There are signs of impact to the rails in several locations. Pier 1 South side exhibits lower rail being bend 4 inches upward and outward. Span 2 median guardrail exhibits damage from collision. No damage or corrosion related distress was noted in any of the railing posts. (see photos 46, 55).

<u>Girders / Paint</u>: The superstructure is a multi-span, multi-girder with a composite concrete deck, having 9 girders under the WB lanes and 8-10 girders under the EB lanes. All girders are plate girders comprised of two varying height by 24" wide flanges and a 50" x ½" web. Ramp H consists of 5 girders which are composed of two varying height by 32" wide flanges and a 66" x ½" web. (see photos 49, 50).

The majority of the end diaphragms located at the East and West abutments, Piers 1 - 14 are in good condition with minor paint loss and corrosion on the bottom flange with the exception of the end diaphragms in piers 3, 6, 9 and 12 where the finger joints allow water to infiltrate and corrode the steel. There are no other holes or cracks detected in the diaphragms. All intermediate diaphragms are in good condition with only scattered areas of minor corrosion or section loss. (see photo 56).

Paint peeling and paint loss with minor surface corrosion is exhibited over approximately 60% of all girders and stringers.

<u>Deck / Fascia</u>: The 8" thick mono-deck is composite with the steel girders by means of girder embedment. Span 1 Bay 13 near diaphragm D1 exhibits a 10 SF spall with exposed rebar, Span 1 Bay 11 D3 exhibits a 10 SF spall with exposed rebar, Span 2 Bay 8 near D4 exhibits a 4SF spall with exposed rebar, Span 2 Bay 12 near pier 1 exhibits a 6 SF spall with exposed rebar, Span 2 Bay 15 near splice location exhibits 18 SF spall with exposed rebar, Span 2 Bay 11 near D2 exhibits a 30 SF spall with exposed rebar, Span 2 Bay 14 near D5 exhibits a 20 SF spall with exposed rebar, Span 3 at middle Joint near D3 exhibits a 6 SF spall with exposed rebar, Span 3 Bay 12 above D3 exhibits a 20 SF hollow section, Span 4 Bay 16 between D3-D4 exhibits a 18 SF spall with exposed rebar, Span 4 Bay 12 between D3-D4 exhibits a 5 SF spall with exposed rebar, Span 5 Bay 16 by D1 exhibits a 8 SF spall with exposed rebar and 12 SF hollow area, Span 5 Bay 17 by D1 exhibits a 8 SF spall with exposed rebar and a 10 SF hollow area, Span 5 Bay 16 between D5-D6 exhibits a 18 SF spall with exposed rebar, Span 6 Bay 17 between D1-D2 exhibits a 18 SF spall with exposed rebar, Span 6 Bay 16 between D1-D2 exhibits a 15 SF spall with exposed rebar, Span 7 Bay 11 by pier 7 exhibits a 16 SF hollow concrete, Span 8 Bay 18 by D1 exhibits a 8 SF spall with exposed rebar, Span 9 Bay 17 by D1 exhibits a 12 SF spall with exposed rebar, Span 9 Bay 13 by D1 exhibits a 12 SF spall with exposed rebar, Span 10 Bay 7 by D3-D4 exhibits a 18 SF spall with exposed rebar, Span 10 Bay 6 by D3-D4 exhibits a 12 SF spall with exposed rebar, Span 11 Bay 12 by D6 exhibits a 8 SF hollow with 1 SF spall with exposed rebar, Span 11 Bay 10 by D1 exhibits a 10 SF spall with exposed rebar, Span 12 Bay 14 by D4 exhibits a 2 SF spall with exposed rebar, Span 13 Bay 15 by D3-D4 exhibits a 4 SF spall with exposed rebar, Span 14 Bay 7 by D1-D2 exhibits a 4 SF spall with exposed rebar, Span 15 Bay 7 by D1-D2 exhibits a 4 SF spall with exposed rebar. (see photos 9 - 30). Ramp H exhibits multiple areas of dampness and map cracking in several location on the underside of deck. (see photo 58). **See the Deck Condition Sketch in Appendix A, for detailed locations of deck spalling, cracking or other deterioration.**

<u>Piers / Pier caps</u>: There are 2 hammerhead piers located at all spans, the North hammerhead pier consists of 9 pedestals and the South pier varies from 8 – 10 pedestals. Pier 1 pedestal 10 exhibits a 2 SF spall with exposed rebar on the NW corner, Pier 3 pedestal 15 exhibits a 1 SF spall with exposed rebar on the North face, Pier 3 pedestal 7 exhibits a 4 LF cracks on the South and West face, Pier 3 North Pier underside exhibits a 16 SF spall with exposed rebar, Pier 6 South Pier cap exhibits several 3' long cracks on the West face, Pier 6 East face under pedestal 18 exhibits a 28 SF spall with exposed rebar, Pier 6 South pier cap underside exhibits a 10 SF spall with exposed rebar, Pier 6 East face pier cap exhibits multiple areas of 4 - 20 SF hollow areas, Pier 8 East face exhibits a 1 SF spall with exposed rebar under pedestal 6, Pier 8 North face of South pier cap exhibits a 6 SF spall with exposed rebar, Pier 9 span 10 side 2 SF spall with exposed rebar and hollow area along entire East face on pedestal 21, Pier 9 back side of pedestal 20 exhibits a 2 SF spall with exposed rebar, Pier 9 span 10 side pedestal 18 exhibits loss of entire North face with a 4 SF spall with exposed rebar, Pier 9 exhibits a 24 SF spall with exposed rebar at East face and underside, Pier 10 north pier underside exhibits a 7 SF spall with exposed rebar and a 40 SF hollow area surrounding, Pier 10 Ramp H side North face of pedestal 4 exhibits a 3 SF spall with exposed rebar, Pier 10 Ramp H side South face of pedestal 3 exhibits a 4 SF spall, Pier 12 span 12 side under pedestal 8 exhibits 2 SF spall with exposed rebar. (see photos 31 - 44).

<u>Sidewalk / Median</u>:

There are no sidewalks located on the bridge.

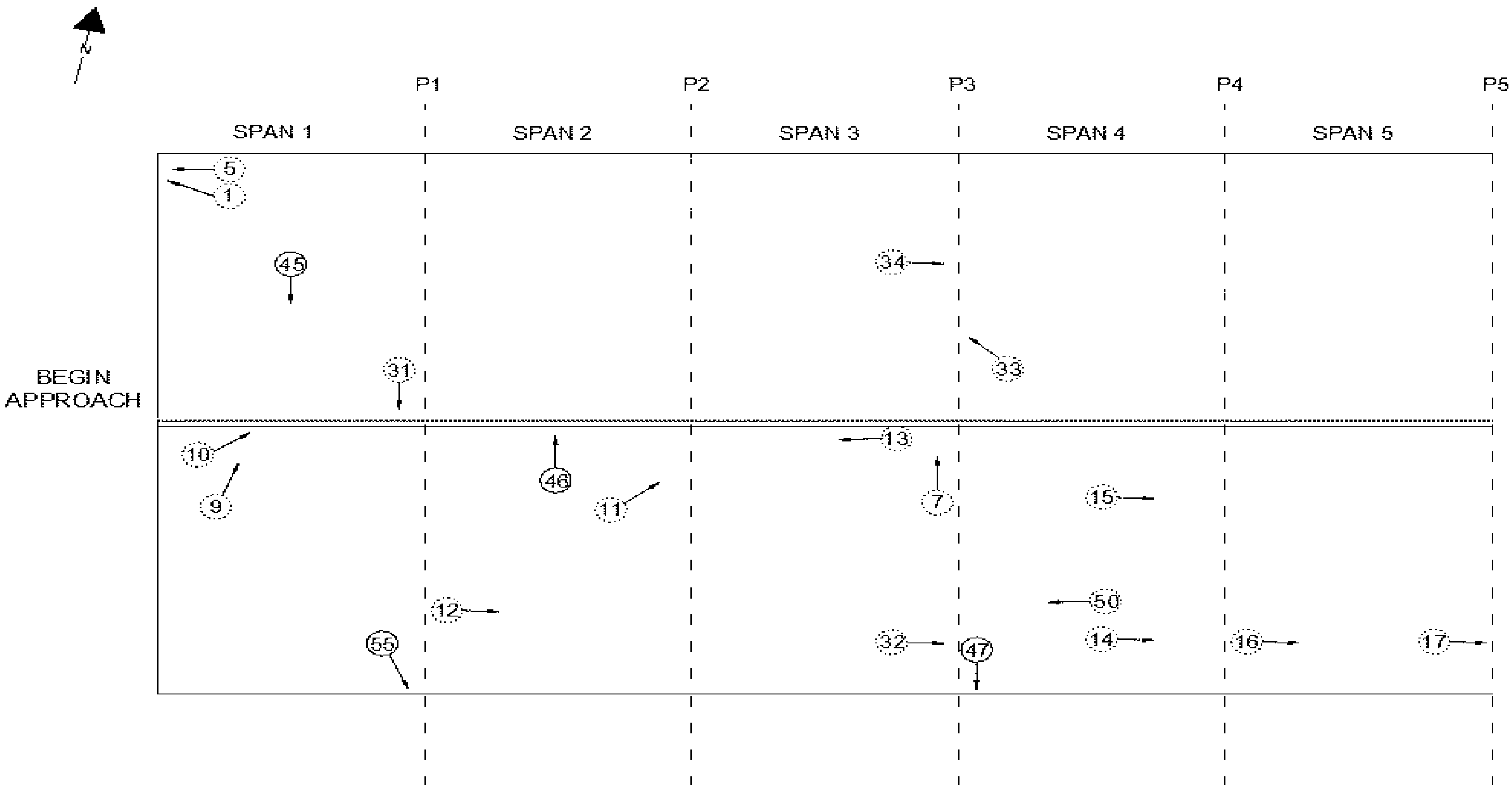
The concrete median is in good condition.

IN-DEPTH PHOTO DOCUMENTATION

IN-DEPTH INSPECTION PHOTO LOCATION PLAN

Grand Central Parkway

Inspection Date: 7/19/2021



BIN: 1-06514-9

LEGEND:

- PHOTO TAKEN ABOVE DECK
- PHOTO TAKEN BELOW DECK

PHOTO LOCATION PLAN

(NOT TO SCALE)

IN-DEPTH INSPECTION PHOTO LOCATION PLAN

Grand Central Parkway

Inspection Date: 7/19/2021

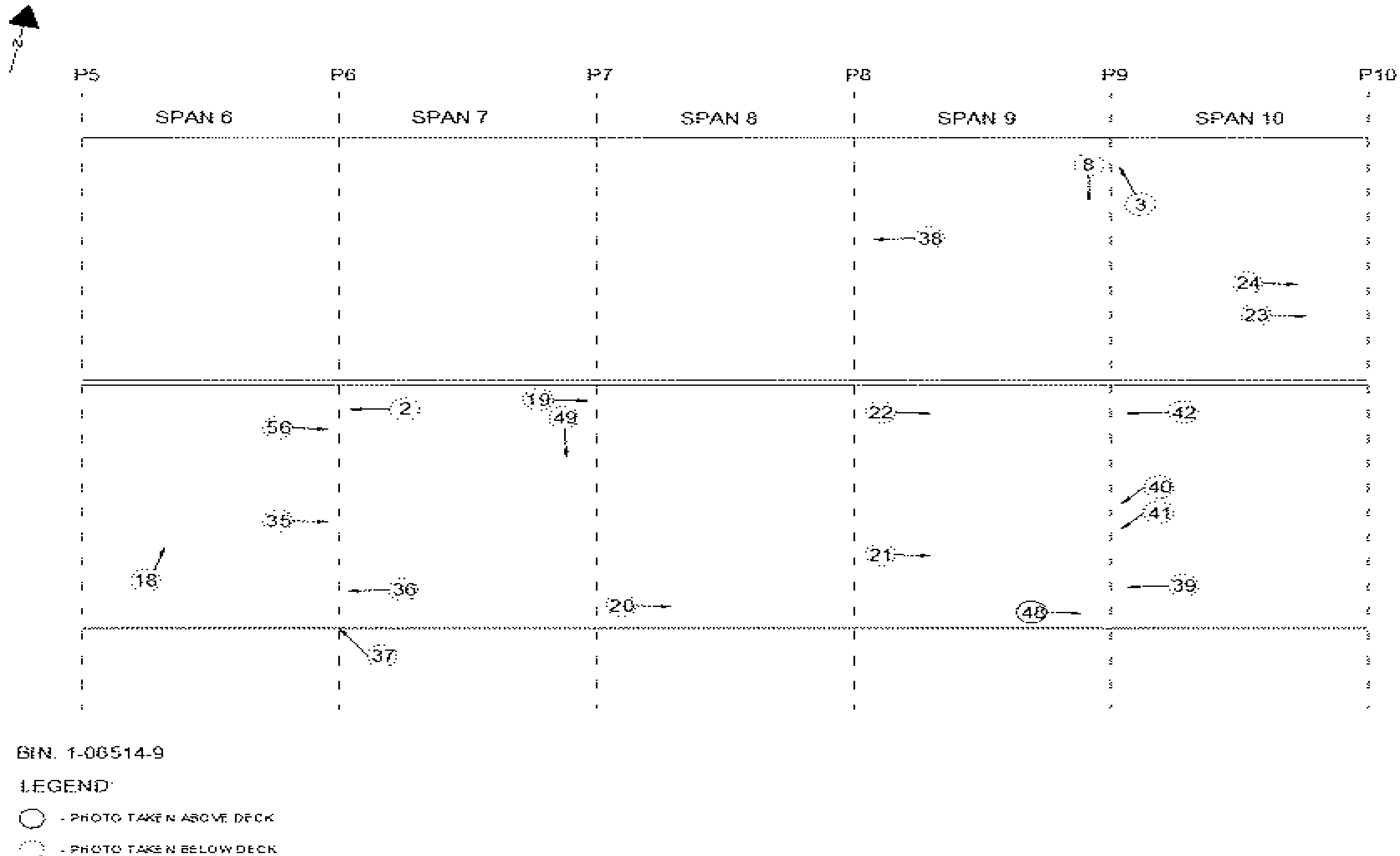
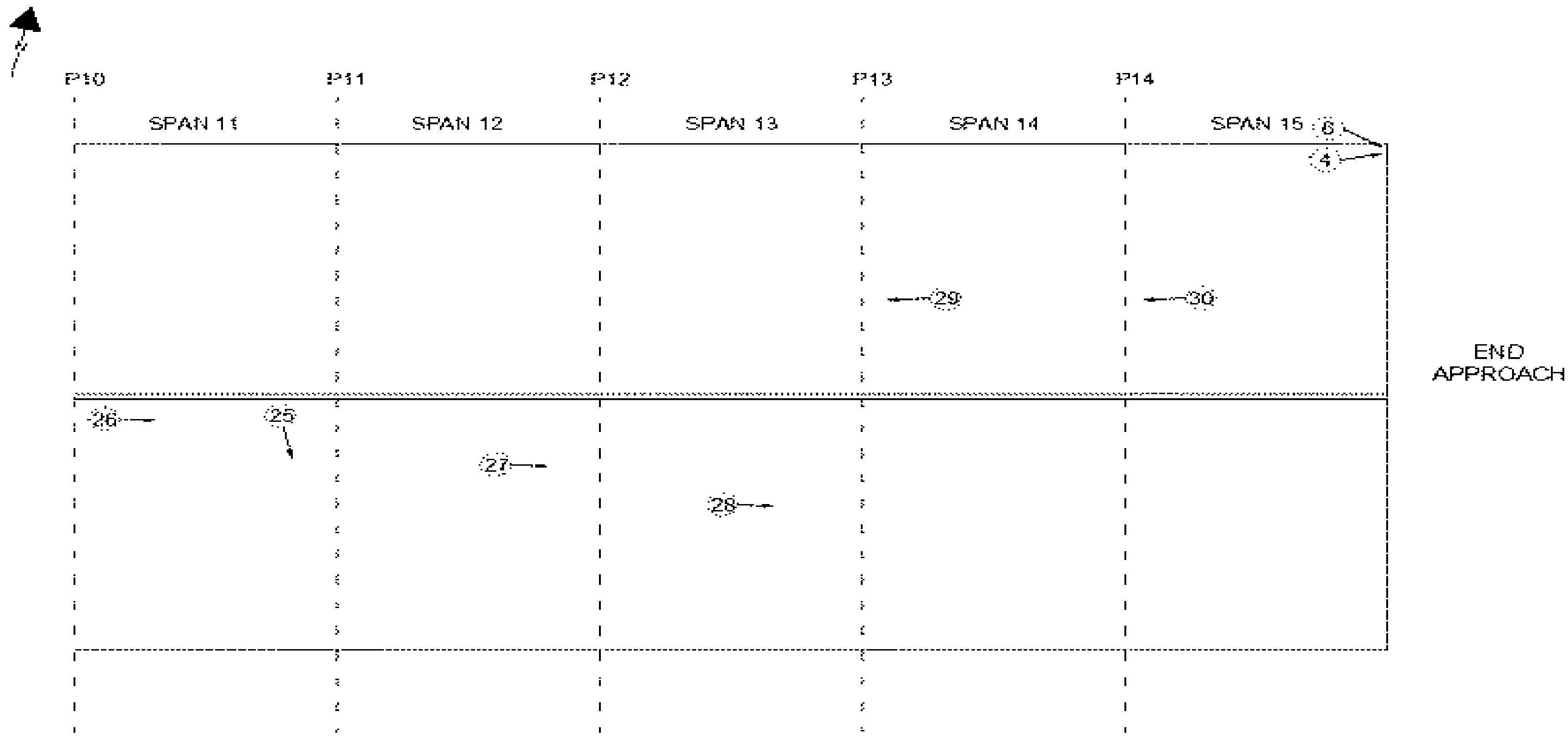


PHOTO LOCATION PLAN
(NOT TO SCALE)

IN-DEPTH INSPECTION PHOTO LOCATION PLAN

Grand Central Parkway

Inspection Date: 7/19/2021



BIN: 1-06514-9

LEGEND:

- PHOTO TAKEN ABOVE DECK

PHOTO TAKEN BELOW DECK

PHOTO LOCATION PLAN

(NOT TO SCALE)

IN-DEPTH INSPECTION PHOTO LOCATION PLAN

Grand Central Parkway

Inspection Date: 7/19/2021

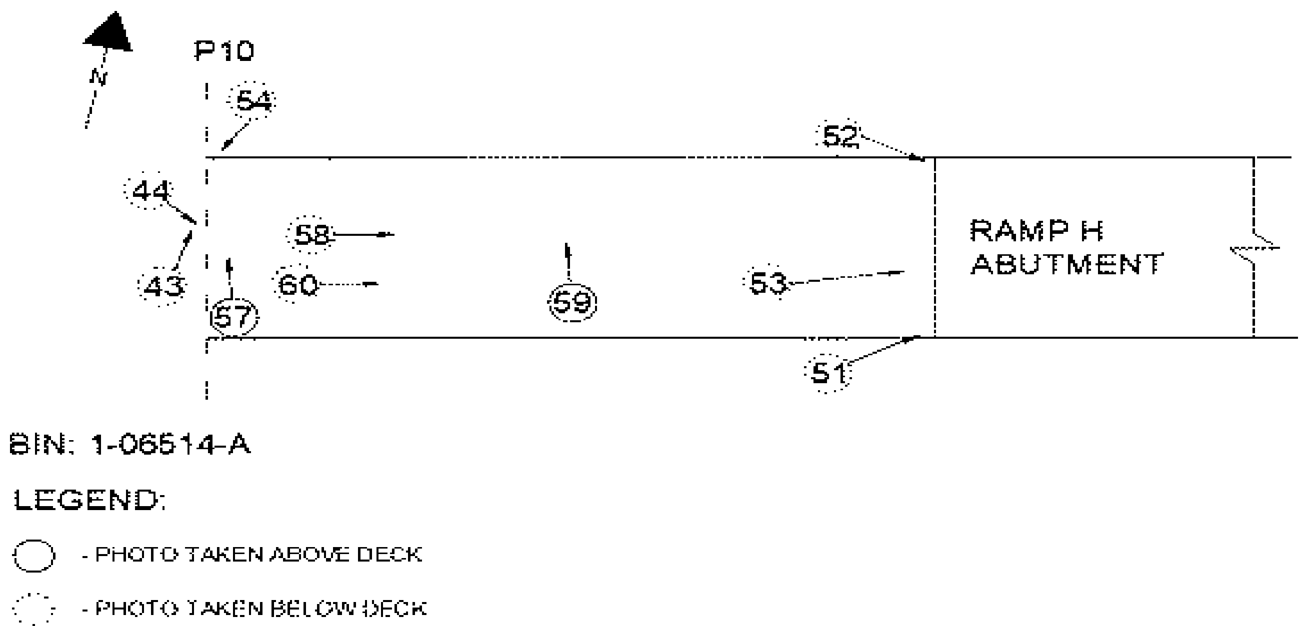


PHOTO LOCATION PLAN
(NOT TO SCALE)

PHOTO: 1 **LOCATION:** West Abutment Bearing under girder G1
DESCRIPTION: Heavy pack rust with deterioration on South anchor bolt nut, Looking West

PHOTO: 2 **LOCATION:** Pier 6 Bearing under girder G12
DESCRIPTION: Heavy bird droppings with deterioration on North anchor bolt nut, Looking West

PHOTO: 3 **LOCATION:** Pier 9 Span 10 side Bearing under girder G2
DESCRIPTION: Bearing exhibits pack rust under rocker, bearing Over-expanded, Looking North

PHOTO: 4 **LOCATION:** East (End) Abutment Bearing under girder G1
DESCRIPTION: Bearing exhibits heavy pack rust and paint chipping, Looking East

PHOTO: 5 **LOCATION:** West Abutment backwall North side behind G1
DESCRIPTION: Backwall exhibits 3" wide by full height with hollow concrete, Looking West

PHOTO: 6 **LOCATION:** East Abutment backwall North side behind G1
DESCRIPTION: Back wall exhibits 3 SF deep spall with exposed rebar Looking East

PHOTO: 7 **LOCATION:** Pier 3 Span 3 side Bay 11
DESCRIPTION: Drainage pipe exhibits heavy corrosion and 5" hole
Looking North

PHOTO: 8 **LOCATION:** Pier 9 Span 9 side Bay 2
DESCRIPTION: Drainage pipe exhibits heavy corrosion and separation
Looking Southeast

PHOTO: 9 **LOCATION:** Span 1 Bay 13 near diaphragm D1
DESCRIPTION: Underside of deck exhibits a 10 SF spall with exposed rebar Looking North

PHOTO: 10 **LOCATION:** Span 1 Bay 11 at diaphragm D3
DESCRIPTION: Underside of deck exhibits a 10 SF spall with exposed rebar Looking Northeast

PHOTO: 11 **LOCATION:** Span 2 Bay 14 at diaphragm D5
DESCRIPTION: 20 SF Spall, Top Flange cross brace, nuts rusted Minor section loss. Looking Northeast

PHOTO: 12 **LOCATION:** Span 2 Bay 15 near diaphragm D1
DESCRIPTION: Underside of deck exhibits a 18 SF spall with exposed rebar Looking East

PHOTO: 13 **LOCATION:** Span 3, Bay 9-11 between diaphragms D2-D3
DESCRIPTION: Underside of deck exhibits 1 SF spall with map cracking and exposed rebar, Looking West

PHOTO: 14 **LOCATION:** Span 4 Bay 16 between diaphragms D3-D4
DESCRIPTION: Underside of deck exhibits 18 SF spall with exposed rebar Looking East

PHOTO: 15 **LOCATION:** Span 4 Bay 12 between diaphragms D3-D4
DESCRIPTION: Underside of deck exhibits a 5 SF spall with exposed rebar Looking East

PHOTO: 16 **LOCATION:** Span 5 Bay 16 between near diaphragm D1
DESCRIPTION: Underside of deck exhibits a 8 SF spall with exposed rebar And 12 SF hollow area, Looking East

PHOTO: 17 **LOCATION:** Span 5 Bay 16 between diaphragms D5-D6
DESCRIPTION: Underside of deck exhibits a 18 SF spall with exposed rebar Looking East

PHOTO: 18 **LOCATION:** Span 6 Bay 16-17 between diaphragms D1-D2
DESCRIPTION: Underside of deck exhibits two 15 SF spalls with exposed rebar, Looking North

PHOTO: 19 **LOCATION:** Span 7 Bay 11 (Joint) at pier 7
DESCRIPTION: Underside of deck exhibits a 16 SF hollow area
Looking East

PHOTO: 20 **LOCATION:** Span 8 Bay 18 near diaphragm D1
DESCRIPTION: Underside of deck exhibits a 8 SF spall with exposed rebar
Looking East

PHOTO: 21 **LOCATION:** Span 9 Bay 17 near diaphragm D1
DESCRIPTION: Underside of deck exhibits a 12 SF spall with exposed rebar Looking East

PHOTO: 22 **LOCATION:** Span 9 Bay 13 near diaphragm D1
DESCRIPTION: Underside of deck exhibits a 12 SF spall with exposed rebar rebar has separated from underside of deck, Looking East

PHOTO: 23 **LOCATION:** Span 10 Bay 7 between diaphragm D3-D4
DESCRIPTION: Underside of deck exhibits a 18 SF spall with exposed rebar Looking East

PHOTO: 24 **LOCATION:** Span 10 Bay 6 between diaphragm D3-D4
DESCRIPTION: Underside of deck exhibits a 12 SF spall with exposed rebar Looking East

PHOTO: 25 **LOCATION:** Span 11 Bay 12 near diaphragm D6
DESCRIPTION: Underside of deck exhibits a 1 SF spall with exposed rebar And 8 SF hollow area, Looking South

PHOTO: 26 **LOCATION:** Span 11 Bay 10 at diaphragm D1
DESCRIPTION: Underside of deck exhibits a 10 SF spall with exposed rebar Looking East

PHOTO: 27 **LOCATION:** Span 12 Bay 14 at diaphragm D4
DESCRIPTION: Underside of deck exhibits a 2 SF spall with exposed rebar Looking East

PHOTO: 28 **LOCATION:** Span 13 Bay 15 between diaphragm D3-D4
DESCRIPTION: Underside of deck exhibits a 4 SF spall with exposed rebar Looking East

PHOTO: 29 **LOCATION:** Span 14 Bay 7 between diaphragm D1-D2
DESCRIPTION: Underside of deck exhibits a 6 SF spall with exposed rebar Looking West

PHOTO: 30 **LOCATION:** Span 15 Bay 7 between diaphragm D1-D2
DESCRIPTION: Underside of deck exhibits a 4 SF spall with exposed rebar Looking West

PHOTO: 31 **LOCATION:** Pier 1 Span 1 side Pedestal 10
DESCRIPTION: Pedestal exhibits a 2 SF spall with exposed rebar and cracking, Looking South

PHOTO: 32 **LOCATION:** Pier 3 Span 3 side Pedestal 15
DESCRIPTION: Pedestal exhibits a 1 SF spall with exposed rebar and cracking, Looking East

PHOTO: 33 **LOCATION:** Pier 3 Span 4 side Pedestal 7
DESCRIPTION: Pedestal exhibits heavy cracking
Looking Northwest

PHOTO: 34 **LOCATION:** Pier 3 North pier underside
DESCRIPTION: Underside of pier exhibits 12 SF spall with exposed rebar
Looking East

PHOTO: 35 **LOCATION:** Pier 6 West face South pier
DESCRIPTION: Pier exhibits multiple cracks with water infiltration Looking East

PHOTO: 36 **LOCATION:** Pier 6 South pier East face and underside by column C4
DESCRIPTION: Underside and face of pier exhibits 28 SF spall with exposed rebar, Looking West

PHOTO: 37 **LOCATION:** Pier 6 South parapet
DESCRIPTION: Parapet exhibits 4 SF spall
Looking Northwest

PHOTO: 38 **LOCATION:** Pier 8 East face by pedestal P6
DESCRIPTION: Pier exhibits 1 SF spall with exposed rebar
Looking West

PHOTO: 39 **LOCATION:** Pier 9 Span 10 side pedestal P21
DESCRIPTION: Pedestal exhibits 2 SF spall with exposed rebar with hollow sounding area along entire East face, Looking West

PHOTO: 40 **LOCATION:** Pier 9 Span 9 side pedestal P17
DESCRIPTION: Pedestal exhibits 2 SF spall with exposed rebar Looking Southwest

B.I.N. 1-06514-9	Grand Central Parkway over the Cross Island Parkway	Date: July 19, 2021 Sheet: 21 of 30

PHOTO: 41 **LOCATION:** Pier 9 Span 10 side pedestal P18
DESCRIPTION: Pedestal exhibits 4 SF spall with exposed rebar
Looking Southwest

PHOTO: 42 **LOCATION:** Pier 9 Span 10 side underside below pedestal P11
DESCRIPTION: Pier exhibits 24 SF spall with exposed rebar
Looking West .

PHOTO: 43 **LOCATION:** Pier 10 underside of North pier below Bay 4 at Ramp H
DESCRIPTION: Pier exhibits 7 SF spall with exposed rebar with 40 SF Hollow surrounding area Looking North

PHOTO: 44 **LOCATION:** Pier 10 Ramp H side pedestal P4
DESCRIPTION: Pedestal exhibits 3 SF spall with exposed rebar Looking East

PHOTO: 45 **LOCATION:** Westbound Span 1 center lane
DESCRIPTION: Deck exhibits a 3 SF by 2” deep spall
Looking South

PHOTO: 46 **LOCATION:** Span 2 Eastbound Left guardrail
DESCRIPTION: Guardrail has a 10’ section damaged
Looking North

PHOTO: 47 **LOCATION:** Pier 3 Eastbound expansion joint South side
DESCRIPTION: Parapet exhibits a 6 SF spall
Looking South

PHOTO: 48 **LOCATION:** Pier 9 expansion joint South end
DESCRIPTION: Pier 9 finger joint filled with debris
Looking East

PHOTO: 49 **LOCATION:** Span 7 bay 10 near pier 7
DESCRIPTION: Cross member connection plate exhibits 2” torsion
Looking South

PHOTO: 50 **LOCATION:** Span 4 bay 15
DESCRIPTION: Typical splice section
Looking West

PHOTO: 51 **LOCATION:** Ramp H abutment
DESCRIPTION: South face of abutment exhibits a 4 SF spall with cracking Looking Northeast

PHOTO: 52 **LOCATION:** Ramp H abutment
DESCRIPTION: North face of abutment exhibits a 4 SF spall with exposed rebar and heavy vegetation Looking East

PHOTO: 53 **LOCATION:** Ramp H abutment
DESCRIPTION: Abutment exhibits large map cracking on face
Looking East

PHOTO: 54 **LOCATION:** Span 10 bearing under girder G1 Ramp H side
DESCRIPTION: Bearing exhibits heavy pack rust
Looking South

PHOTO: 55 **LOCATION:** Pier 1 Top of Deck
DESCRIPTION: Guardrail on South side exhibits lower rail bent up and out approximately 4 inches, Looking South

PHOTO: 56 **LOCATION:** Pier 6 bay 12 End Diaphragm
DESCRIPTION: End diaphragm exhibits heavy rust due to Looking South

B.I.N. 1-06514-9	Grand Central Parkway over the Cross Island Parkway	Date: July 19, 2021 Sheet: 29 of 31

PHOTO: 57 **LOCATION:** Ramp H Top of Deck near Pier 10
DESCRIPTION: Deck exhibits a 2 SF spall with exposed rebar, asphalt patch worn away, Looking North

PHOTO: 58 **LOCATION:** Ramp H Underside of Deck
DESCRIPTION: Underside of deck displays areas paint chipping, splice shown approximately 40’ East of Pier 10, Looking East

PHOTO: 59 **LOCATION:** Ramp H Top of Deck near midspan
DESCRIPTION: Deck exhibits a 1 SF spall with exposed rebar and a 0.5 SF spall, Looking North

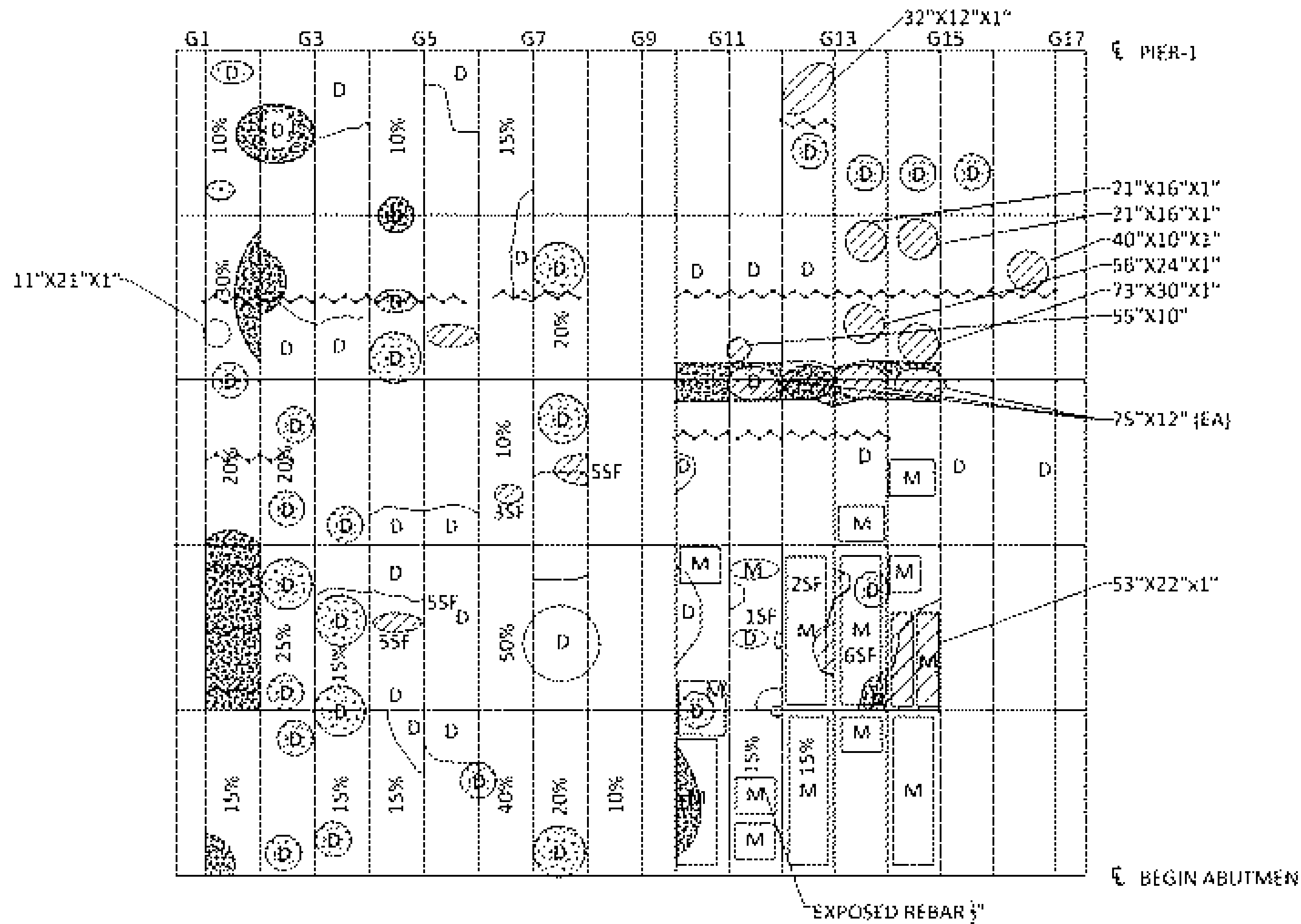
PHOTO: 60 **LOCATION:** Ramp H Underside of Deck
DESCRIPTION: Underside of deck displays areas of dampness and map cracking, Looking East

APPENDIX A

STRUCTURAL DECK CONDITION

NORTH

SPAN 1
UNDERSIDE OF DECK SKETCH

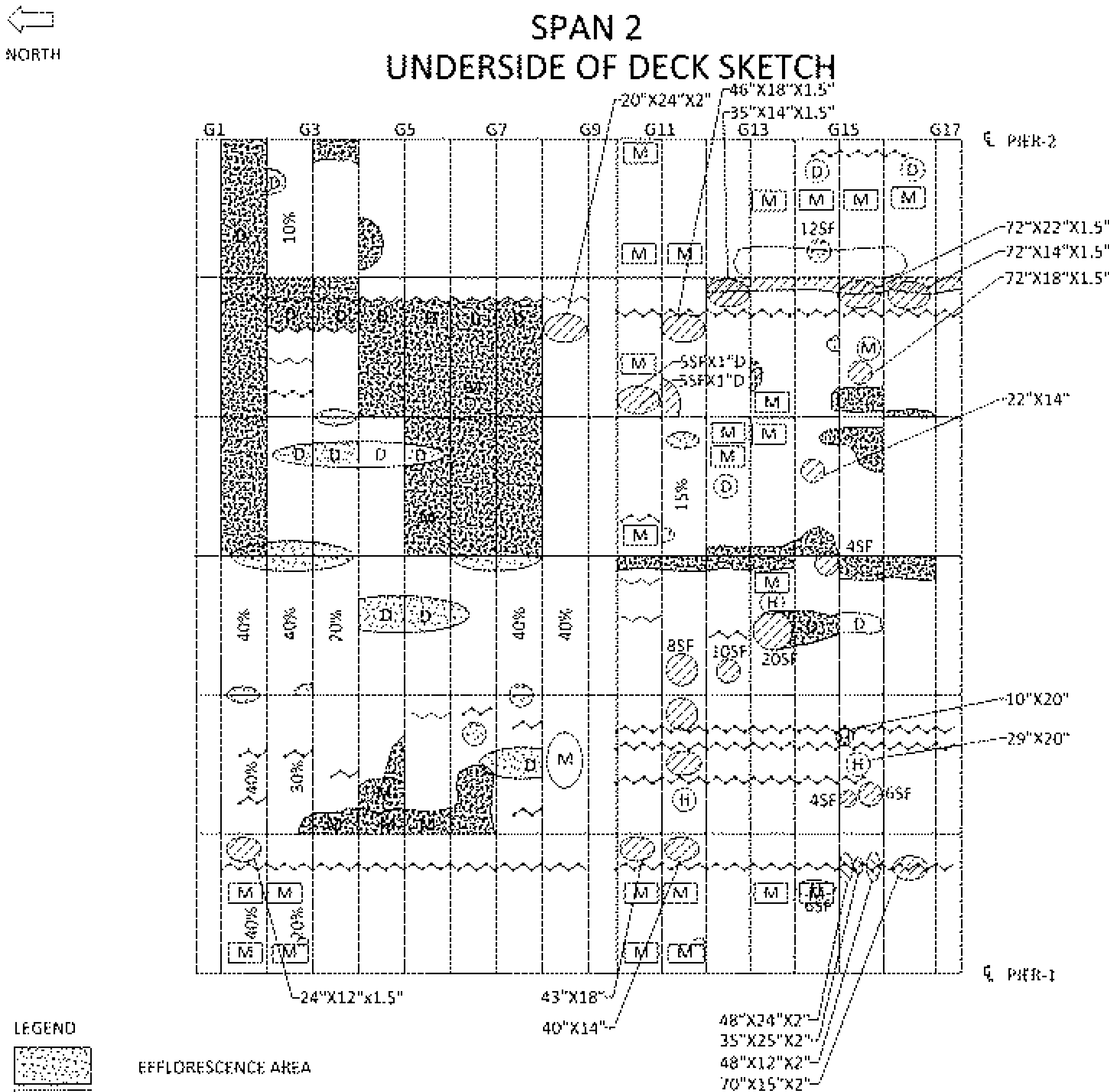


LEGEND

	EFFLORESCENCE AREA
M	MAP CRACKING AREA
	SPALL WITH EXPOSED REBAR
D	DAMPNESS
	CRACK (UP TO ⅛")
	CRACK WITH EFFLORESCENCE (UP TO ⅛")

% OF UNDERSIDE OF DECK AREA WITH DAMPNESS/LEAKAGE

SPAN 2
UNDERSIDE OF DECK SKETCH



LEGEND

EFFLORESCENCE AREA

M — MAP CRACKING AREA

SPALL WITH EXPOSED REBAR

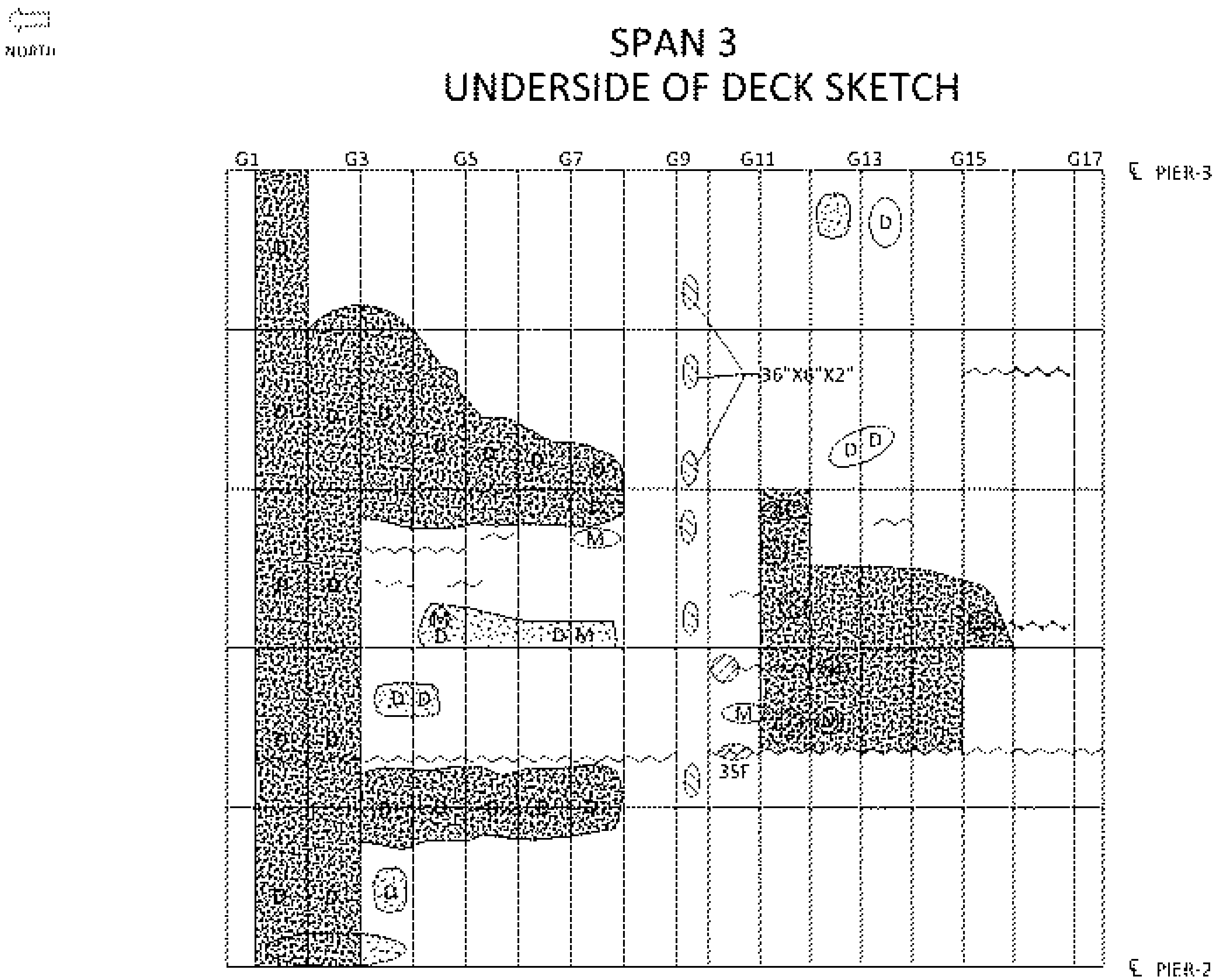
D — DAMPNESS

CRACK (UP TO ⅛")

CRACK WITH EFFLORESCENCE (UP TO ⅛")

% OF UNDERSIDE OF DECK AREA WITH DAMPNESS/LEAKAGE

SPAN 3
UNDERSIDE OF DECK SKETCH



LEGEND

EFFLORESCENCE AREA

M MAP CRACKING AREA

SPALL WITH EXPOSED REBAR

D DAMPNESS

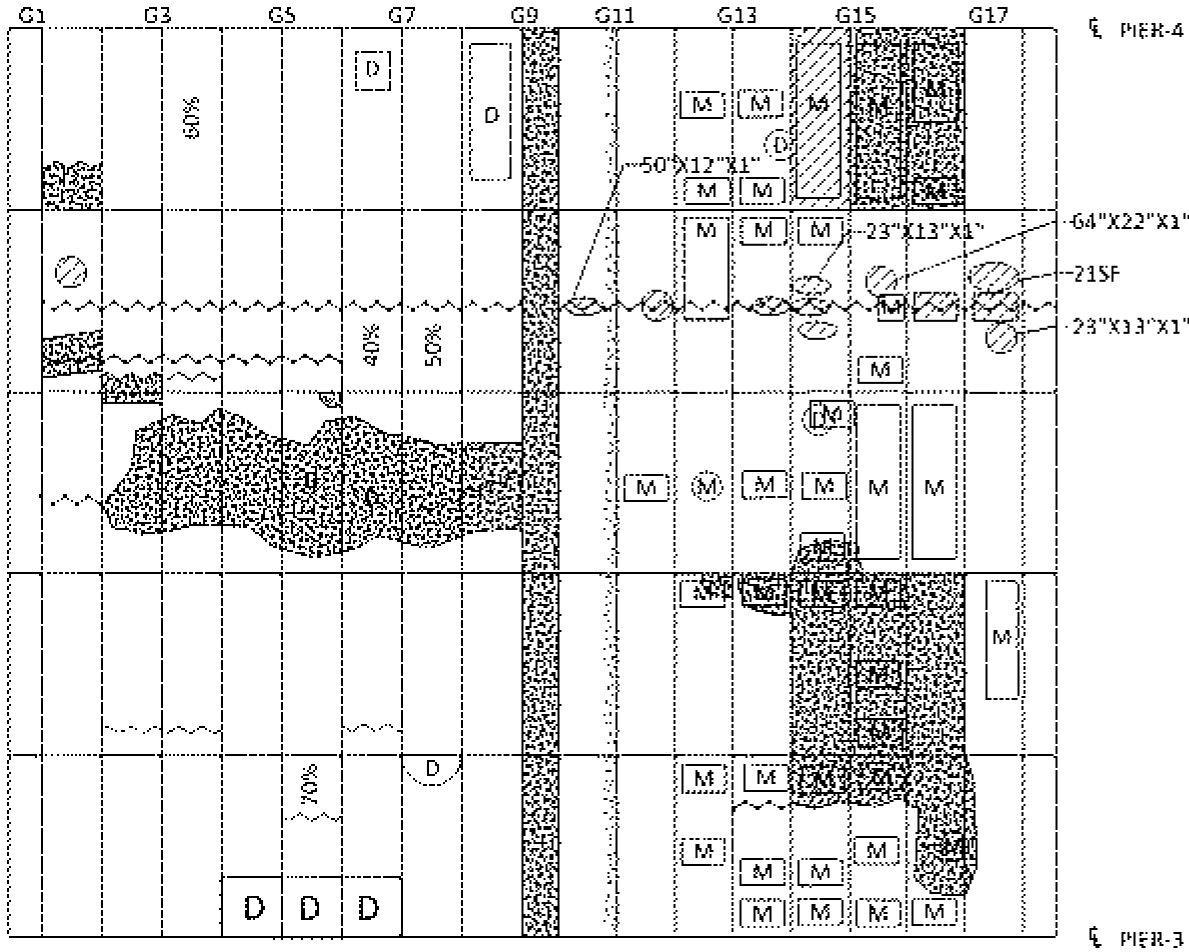
CRACK (UP TO ½")

CRACK WITH EFFLORESCENCE (UP TO ¾")

% OF UNDERSIDE OF DECK AREA WITH DAMPNESS/LEAKAGE

NORTH

SPAN 4
UNDERSIDE OF DECK SKETCH



LEGEND

EFFLORESCENCE AREA

MAP CRACKING AREA

SPALL WITH EXPOSED REBAR

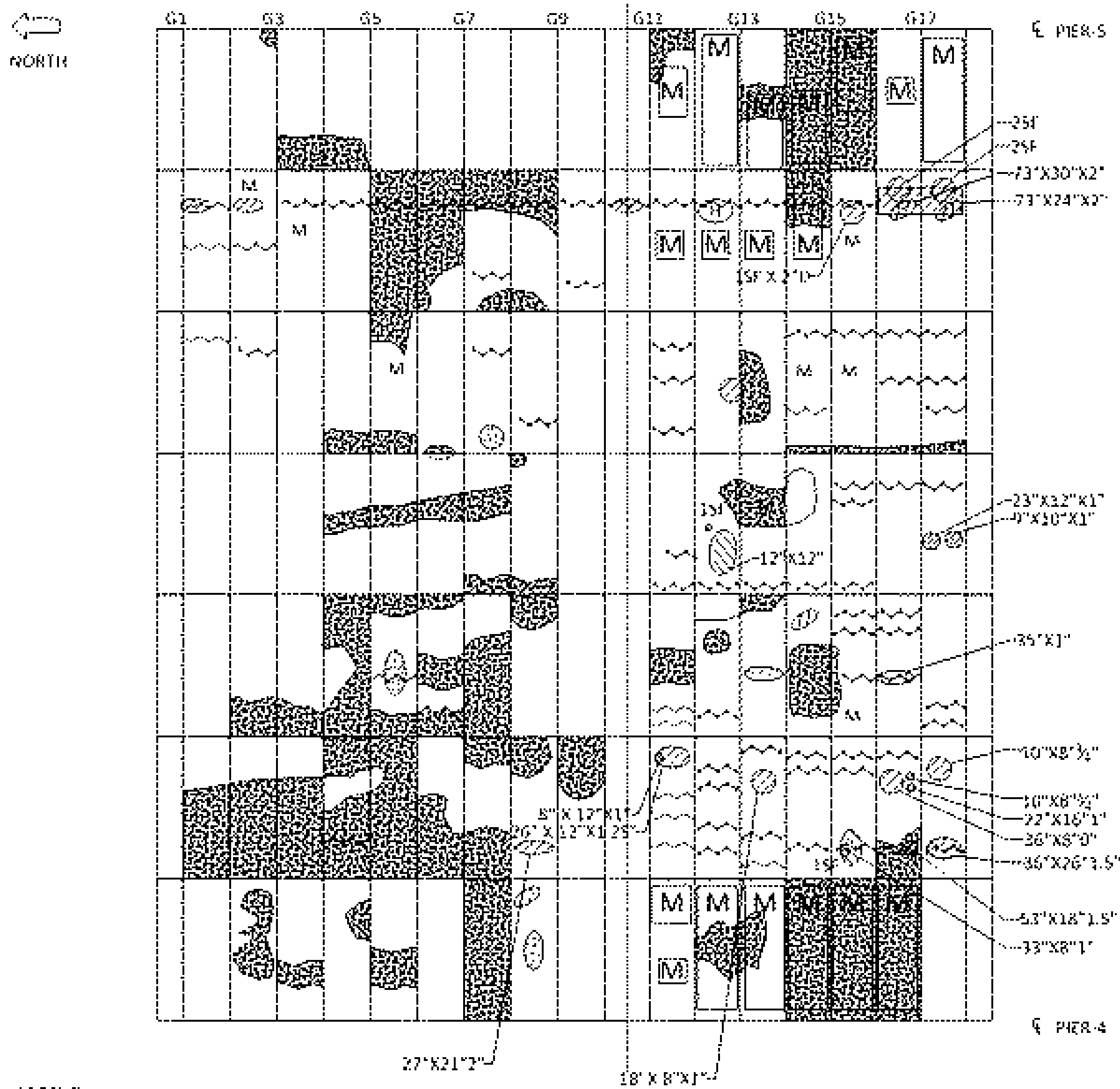
DAMPNESS

CRACK (UP TO ¼")

CRACK WITH EFFLORESCENCE (UP TO ¼")

% OF UNDERSIDE OF DECK AREA WITH DAMPNESS/LEAKAGE

SPAN 5
UNDERSIDE OF DECK SKETCH



LEGEND

EFFLORESCENCE AREA

M MAP CRACKING AREA

SPALL WITH EXPOSED REBAR

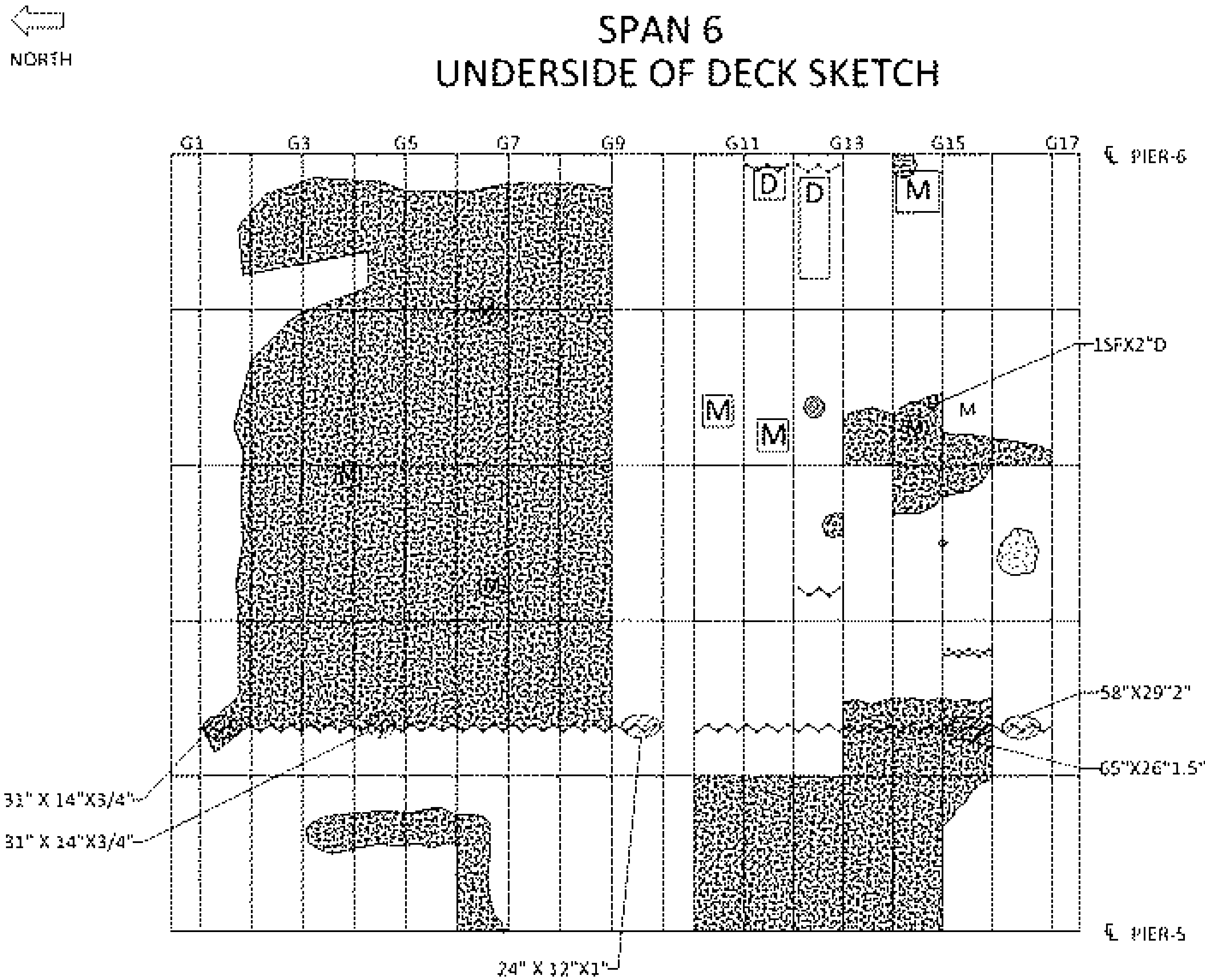
D DAMPNESS

CRACK (UP TO ½")

CRACK WITH EFFLORESCENCE (UP TO ½")

% OF UNDERSIDE OF DECK AREA WITH DAMPNESS/LEAKAGE

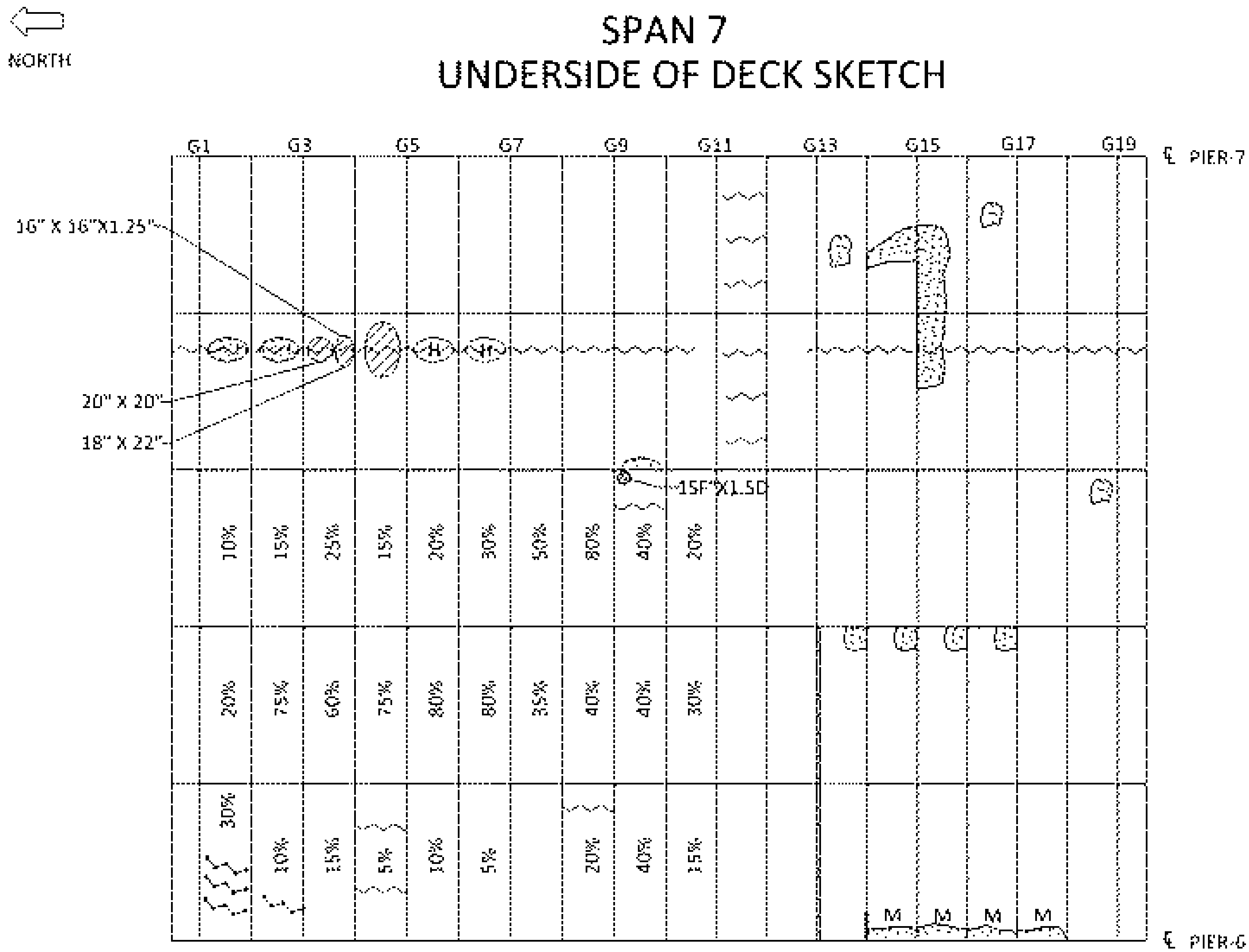
SPAN 6
UNDERSIDE OF DECK SKETCH



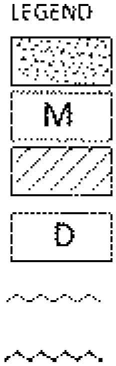
LEGEND

	EFFLORESCENCE AREA
M	MAP CRACKING AREA
	SPALL WITH EXPOSED REBAR
D	DAMPNESS
	CRACK (UP TO ½")
	CRACK WITH EFFLORESCENCE (UP TO ¼")
%	OF UNDERSIDE OF DECK AREA WITH DAMPNESS/LEAKAGE

SPAN 7
UNDERSIDE OF DECK SKETCH



LEGEND



EFFLORESCENCE AREA

MAP CRACKING AREA

SPALL WITH EXPOSED REBAR

DAMPNESS

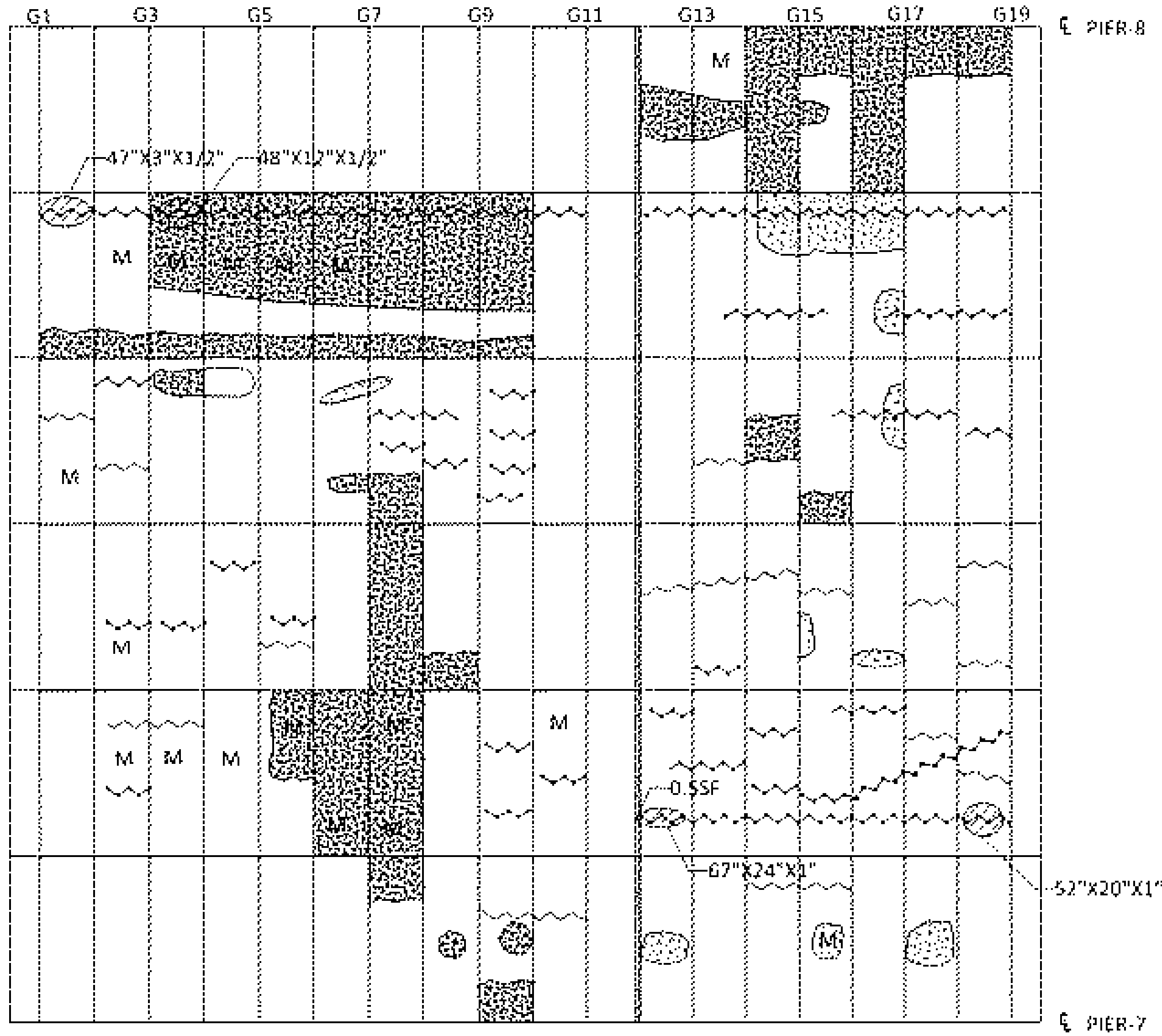
CRACK (UP TO ¼")

CRACK WITH EFFLORESCENCE (UP TO ¼")

% OF UNDERSIDE OF DECK AREA WITH DAMPNESS/LEAKAGE

NORTH

SPAN 8
UNDERSIDE OF DECK SKETCH



LEGEND

EFFLORESCENCE AREA

M — MAP CRACKING AREA

SPALL WITH EXPOSED REBAR

D — DAMPNESS

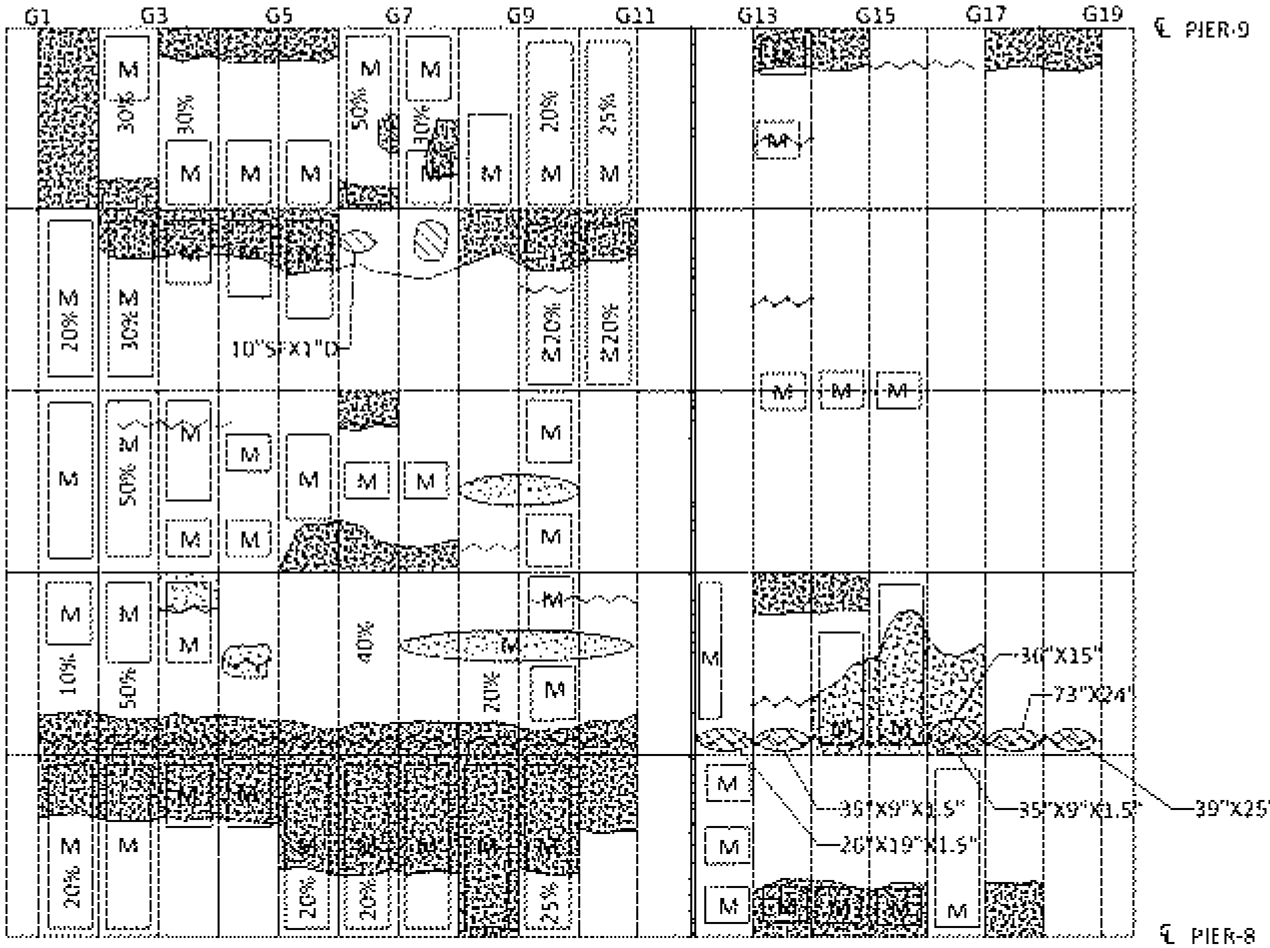
CRACK (UP TO ¼")

CRACK WITH EFFLORESCENCE (UP TO ¼")

% OF UNDERSIDE OF DECK AREA WITH DAMPNESS/LEAKAGE

NORTH

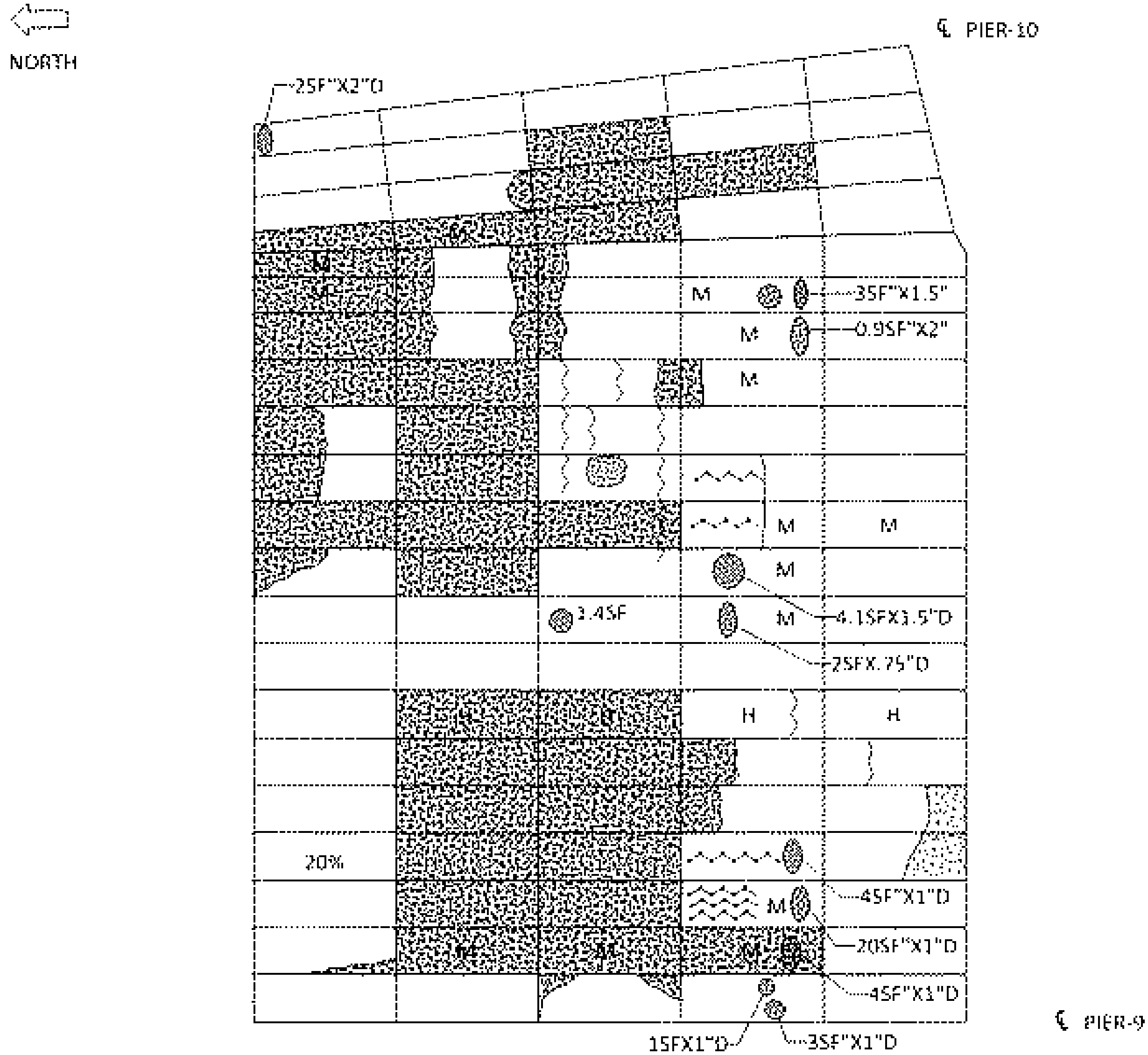
SPAN 9
UNDERSIDE OF DECK SKETCH



LEGEND

	EFFLORESCENCE AREA
M	MAP CRACKING AREA
	SPALL WITH EXPOSED REBAR
D	DAMPNESS
	CRACK (UP TO ¼")
	CRACK WITH EFFLORESCENCE (UP TO ¼")
%	OF UNDERSIDE OF DECK AREA WITH DAMPNESS/LEAKAGE

SPAN 10
UNDERSIDE OF DECK SKETCH



LEGEND

EFFLORESCENCE AREA

M — MAP CRACKING AREA

SPALL WITH EXPOSED REBAR

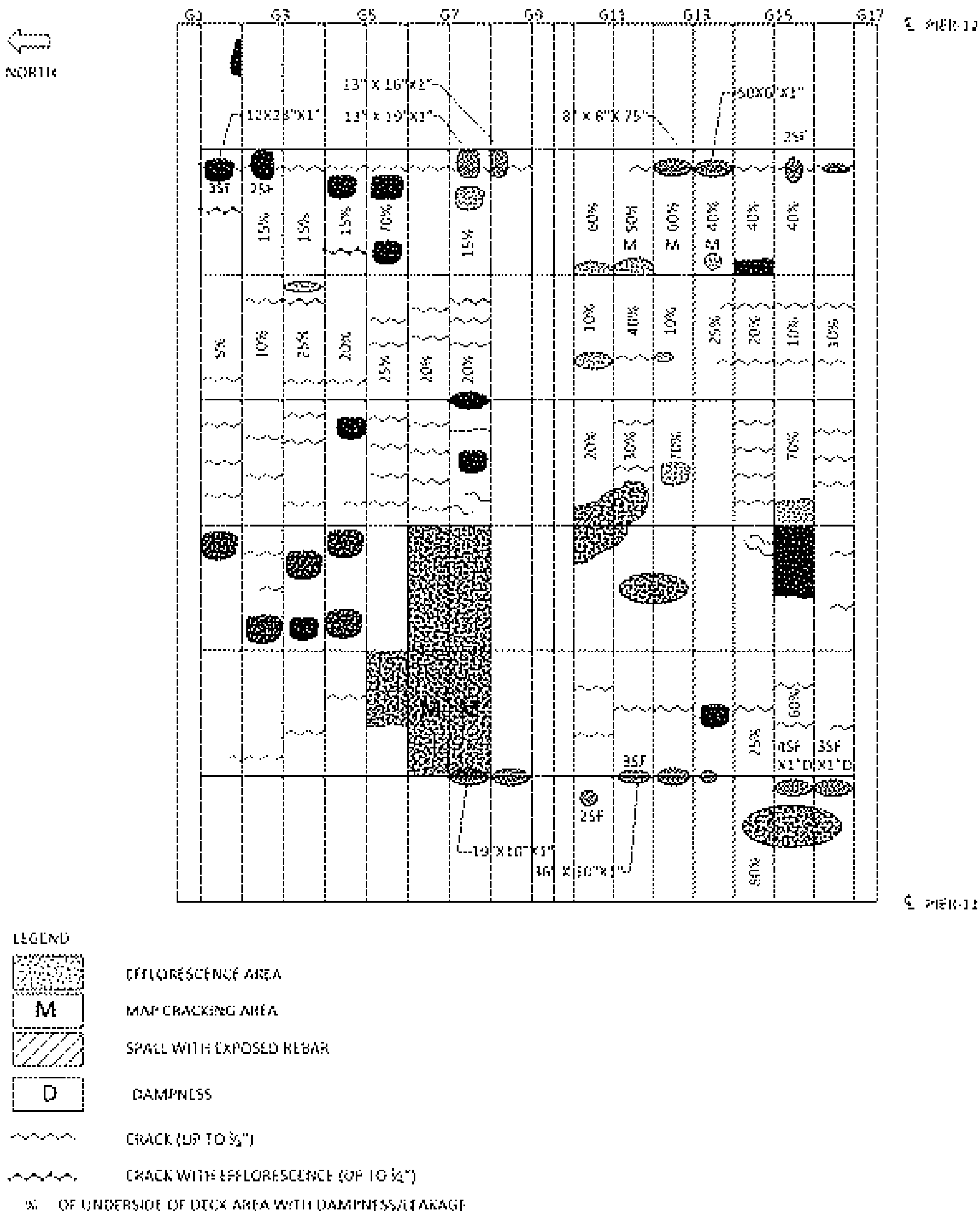
D — DAMPNESS

CRACK (UP TO ¼")

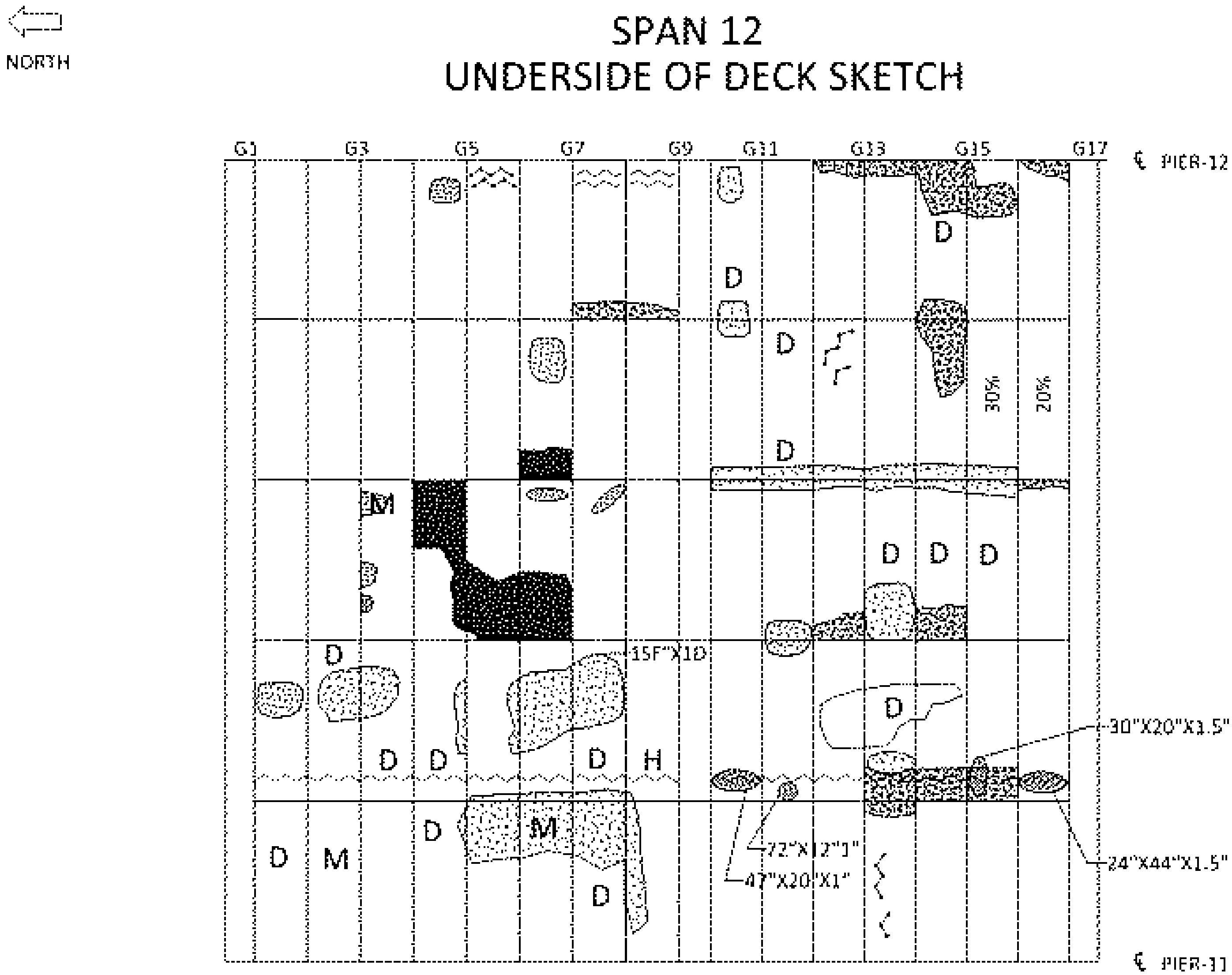
CRACK WITH EFFLORESCENCE (UP TO ½")

% OF UNDERSIDE OF DECK AREA WITH DAMPNESS/LEAKAGE

SPAN 11
UNDERSIDE OF DECK SKETCH



SPAN 12
UNDERSIDE OF DECK SKETCH

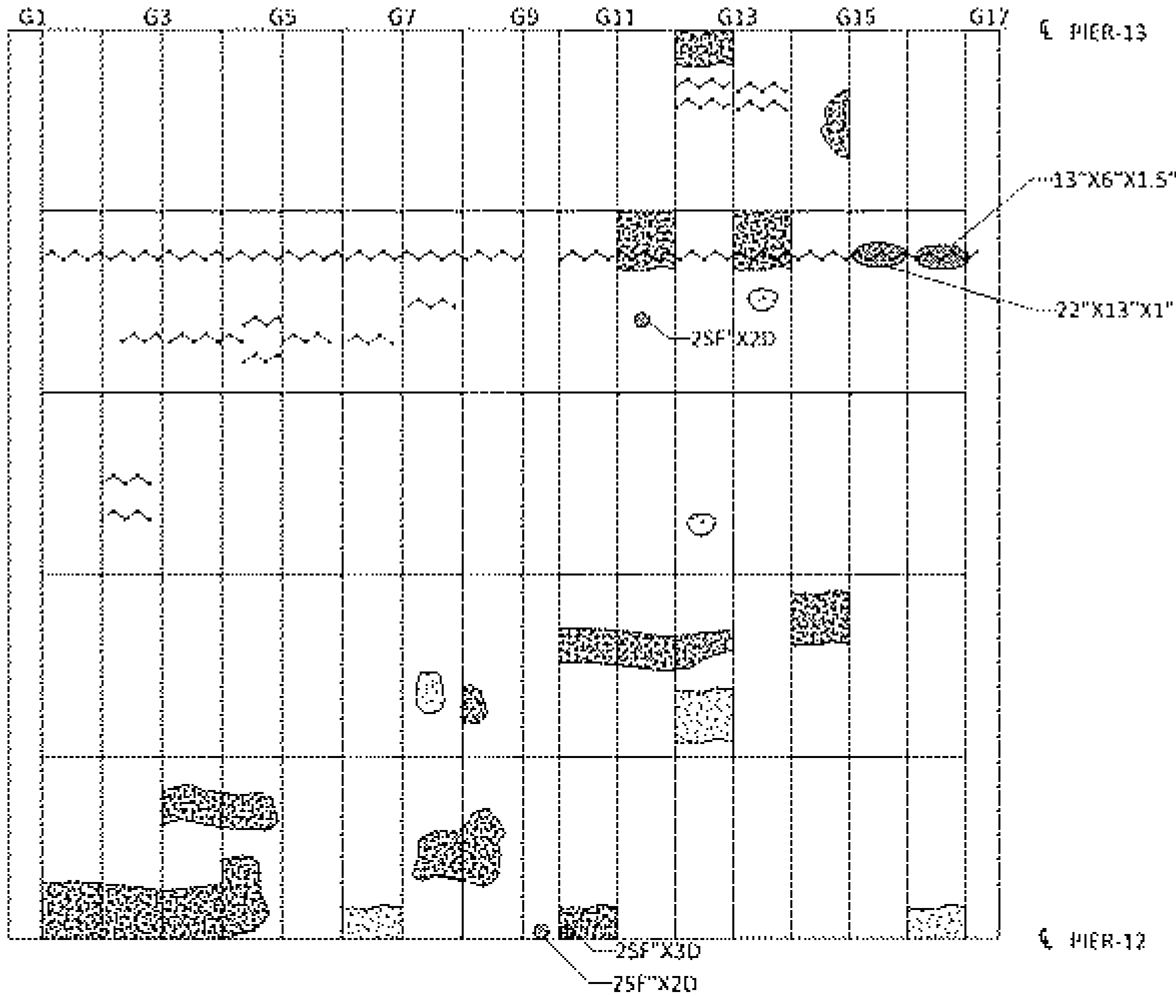


LEGEND

	EFFLORESCENCE AREA
M	MAP CRACKING AREA
	SPALL WITH EXPOSED REBAR
D	DAMPNESS
	CRACK (UP TO ¼")
	CRACK WITH EFFLORESCENCE (UP TO ½")
%	OF UNDERSIDE OF DECK AREA WITH DAMPNESS/LEAKAGE

NORTH

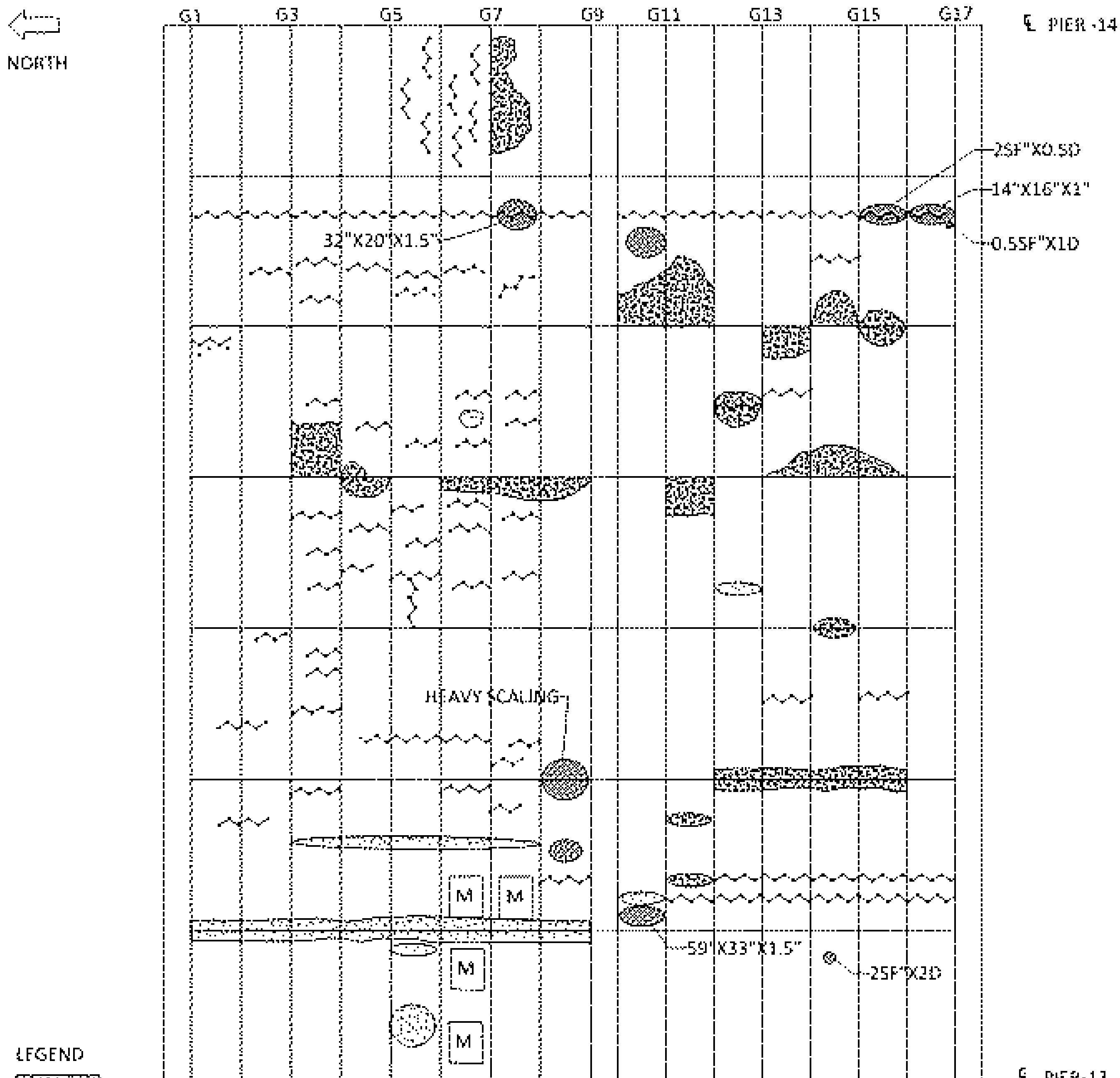
SPAN 13
UNDERSIDE OF DECK SKETCH



LEGEND

	EFFLORESCENCE AREA
M	MAP CRACKING AREA
	SPALL WITH EXPOSED REBAR
D	DAMPNESS
	CRACK (UP TO ¼")
	CRACK WITH EFFLORESCENCE (UP TO ½")
%	OF UNDERSIDE OF DECK AREA WITH DAMPNESS/LEAKAGE

SPAN14
UNDERSIDE OF DECK SKETCH



LEGEND

EFFLORESCENCE AREA

M MAP CRACKING AREA

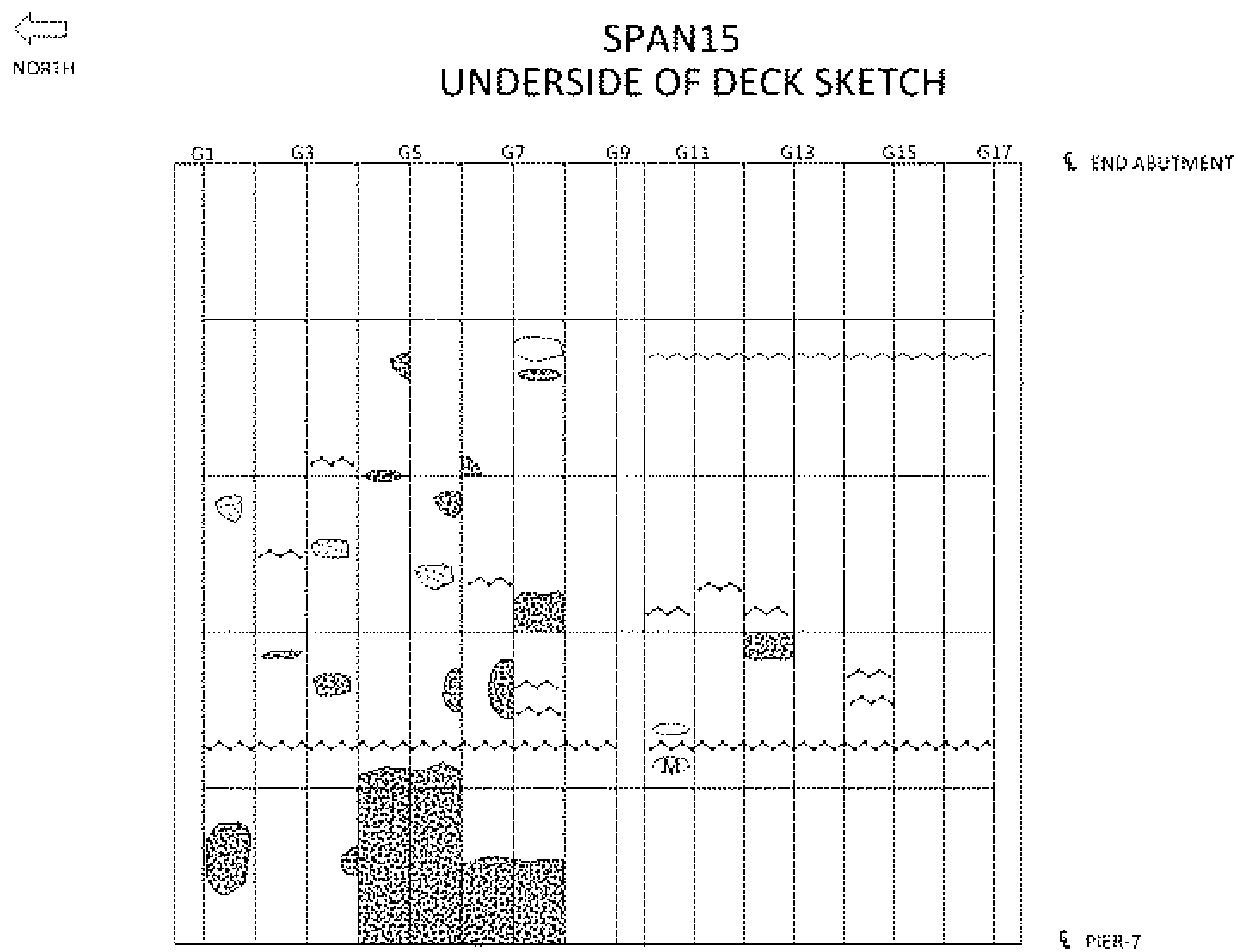
SPALL WITH EXPOSED REBAR

D DAMPNESS

CRACK (UP TO ½")

CRACK WITH EFFLORESCENCE (UP TO ½")

% OF UNDERSIDE OF DECK AREA WITH DAMPNESS/LEAKAGE



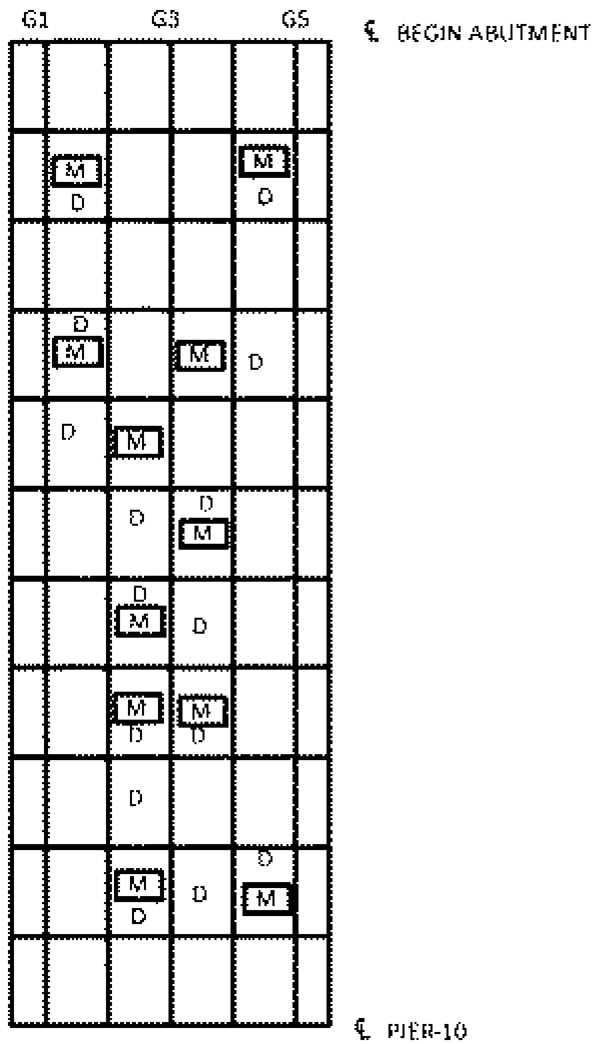
SPAN15
UNDERSIDE OF DECK SKETCH

LEGEND

	EFFLORESCENCE AREA
M	MAP CRACKING AREA
	SPALL WITH EXPOSED REBAR
D	DAMPNESS
	CRACK (UP TO ½")
	CRACK WITH EFFLORESCENCE (UP TO ¼")
%	OF UNDERSIDE OF DECK AREA WITH DAMPNESS/LEAKAGE

NORTH

RAMP H
UNDERSIDE OF DECK SKETCH

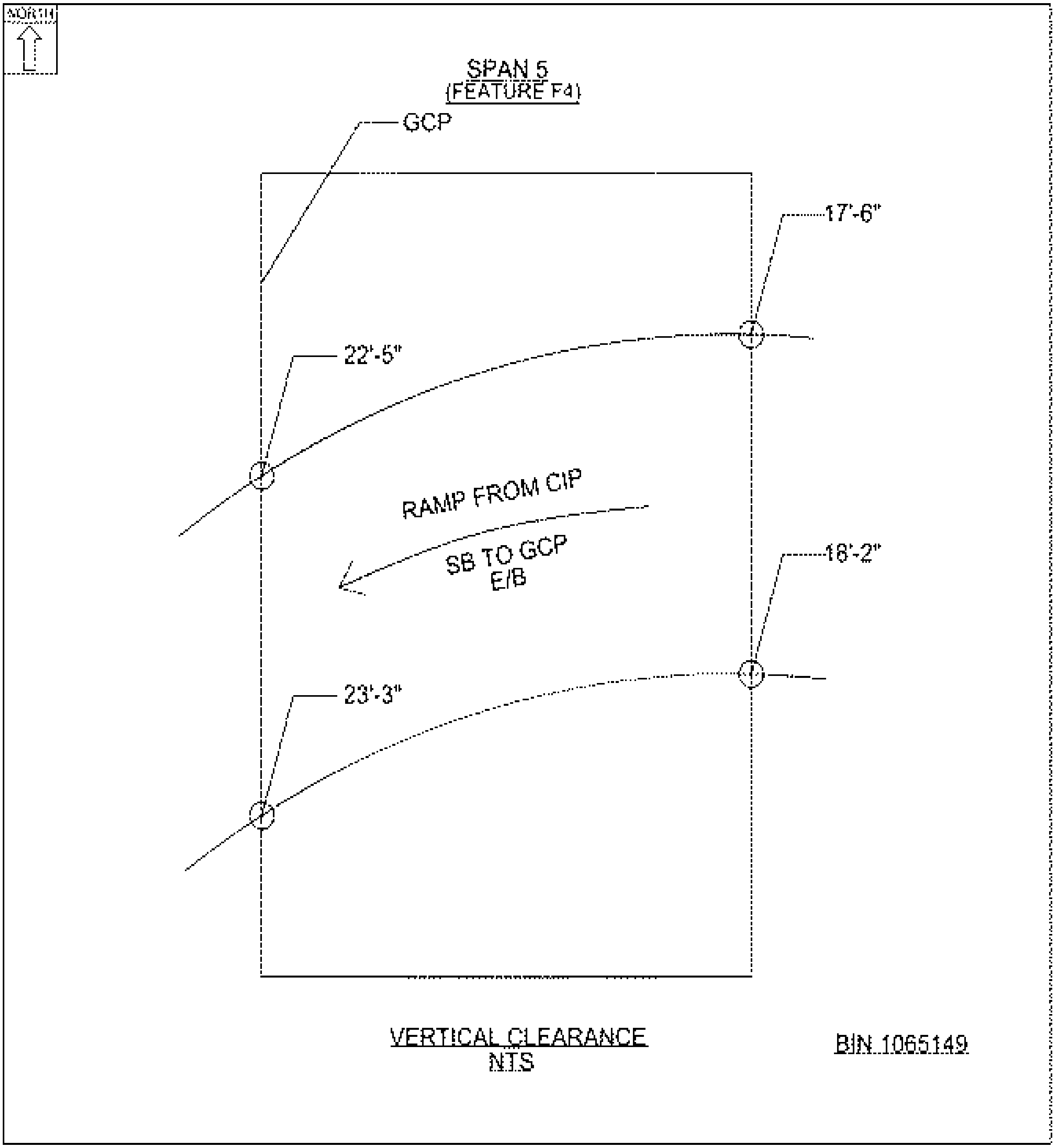


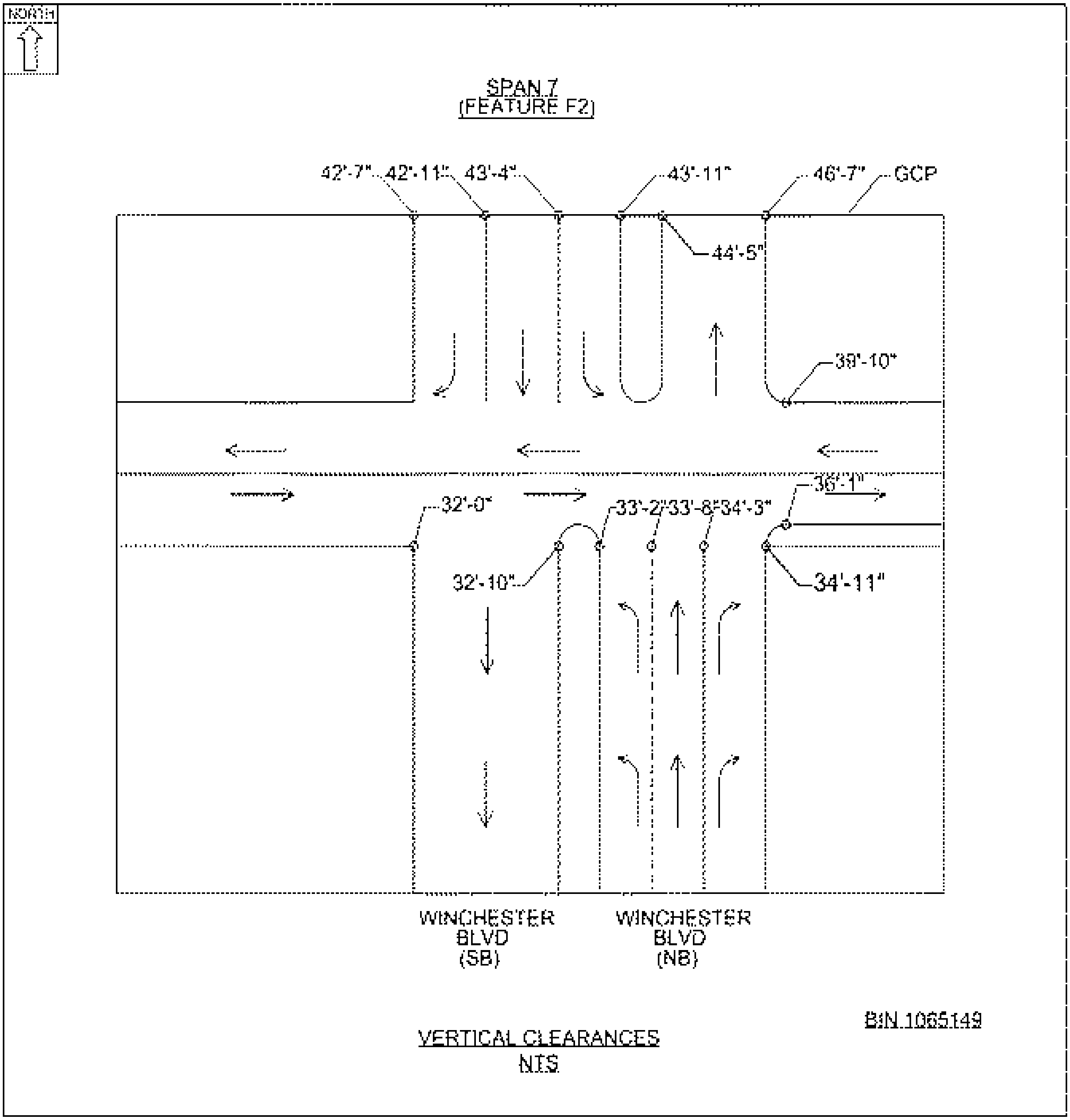
LEGEND

- EFFLORESCENCE AREA
- M MAP CRACKING AREA
- SPALL WITH EXPOSED REBAR
- D DAMPNESS
- CRACK (UP TO ¼")
- CRACK WITH EFFLORESCENCE (UP TO ¼")

% OF UNDERSIDE OF DECK AREA WITH DAMPNESS/LEAKAGE

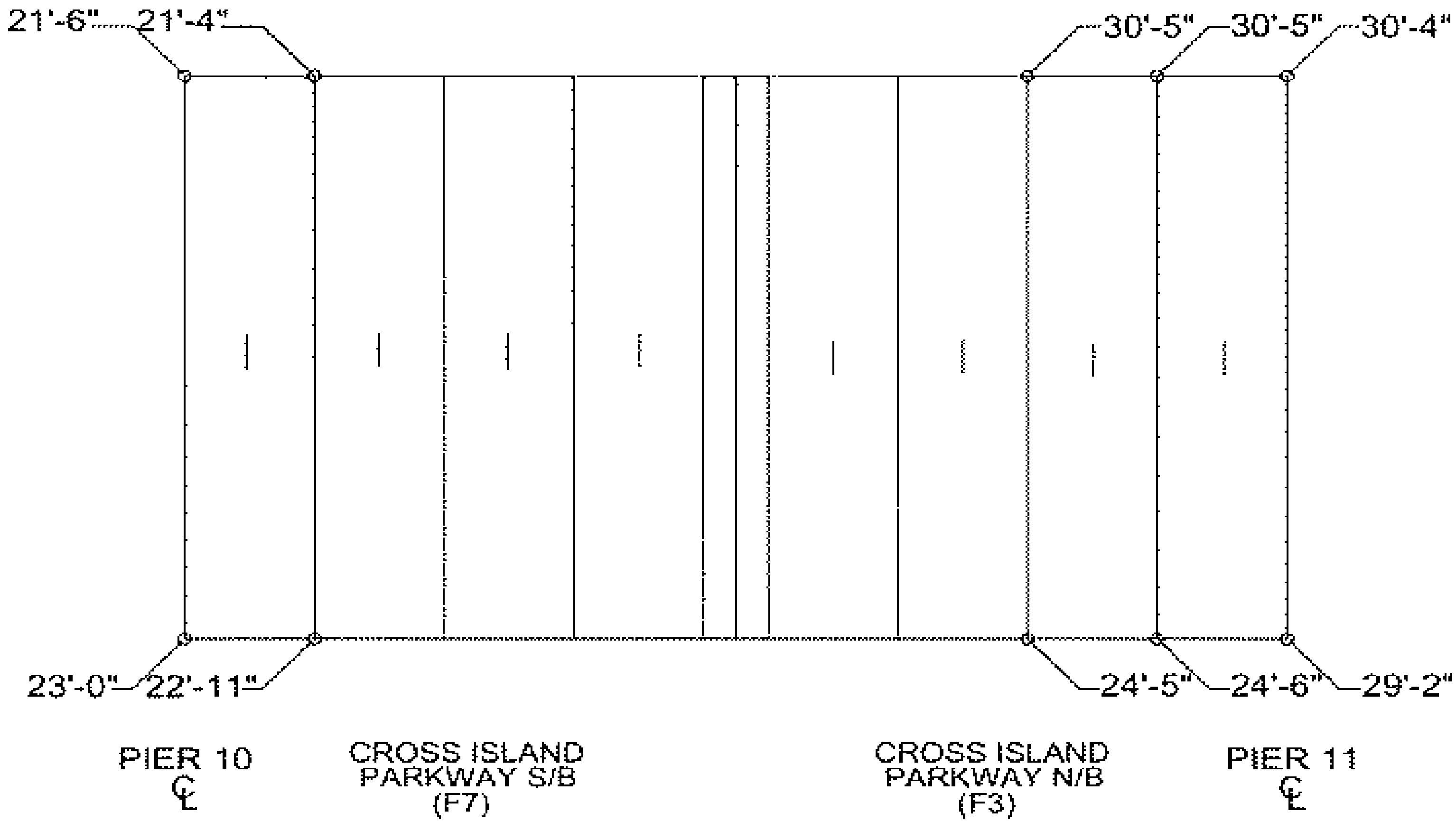
VERTICAL CLEARANCES


NORTH
SPAN 5
(FEATURE F4)
GCP
17'-6"
22'-5"
RAMP FROM CIP
SB TO GCP
E/B
18'-2"
23'-3"
VERTICAL CLEARANCE
NTS
BIN 1065149



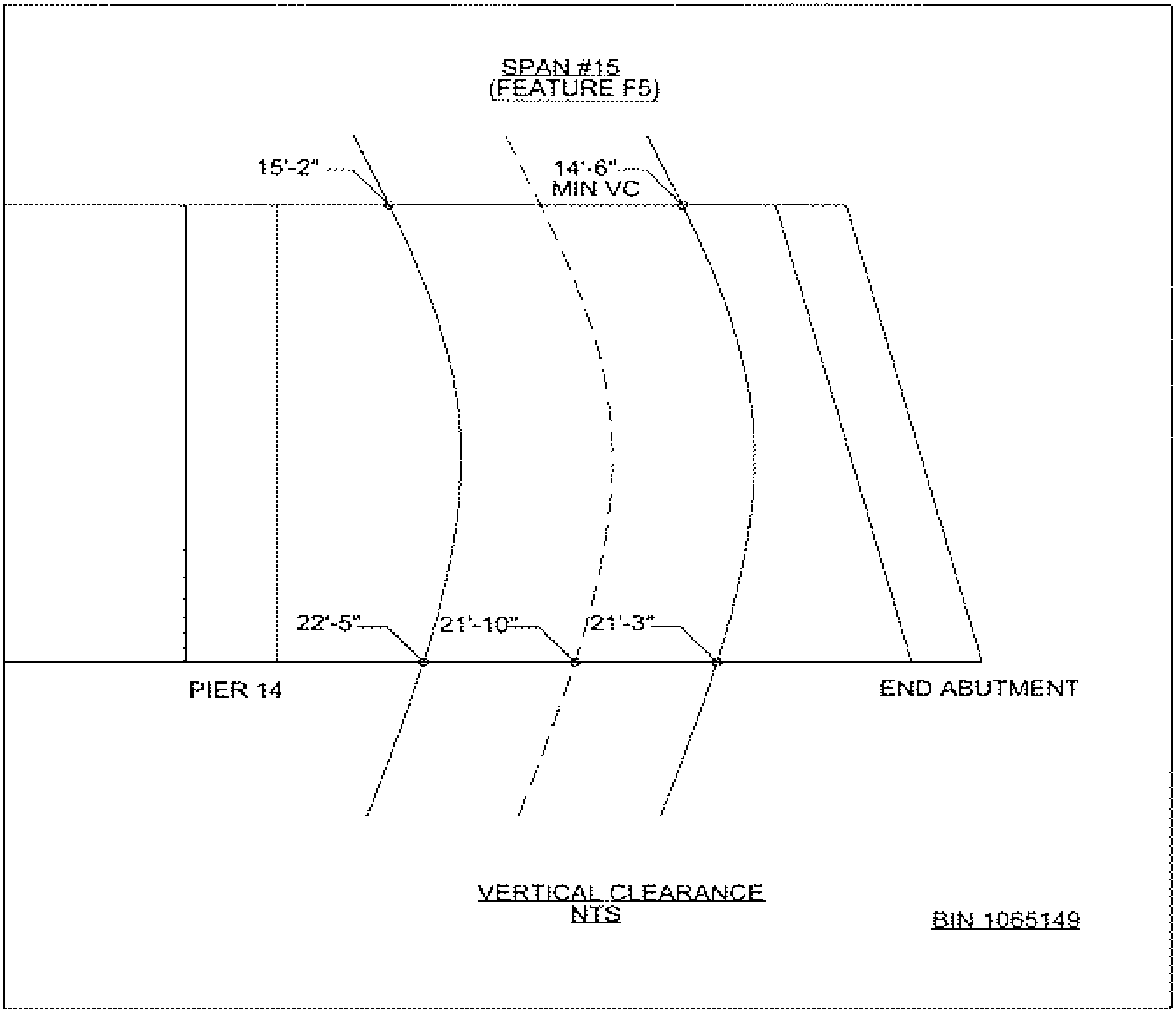
NORTH
SPAN 7
(FEATURE F2)
42'-7"
42'-11"
43'-4"
43'-11"
46'-7"
GCP
44'-5"
39'-10"
36'-1"
32'-0"
33'-2"
33'-8"
34'-3"
32'-10"
34'-11"
WINCHESTER BLVD (SB)
WINCHESTER BLVD (NB)
BIN 1065149
VERTICAL CLEARANCES
NTS

SPAN # 11
(FEATURE F3 & F7)



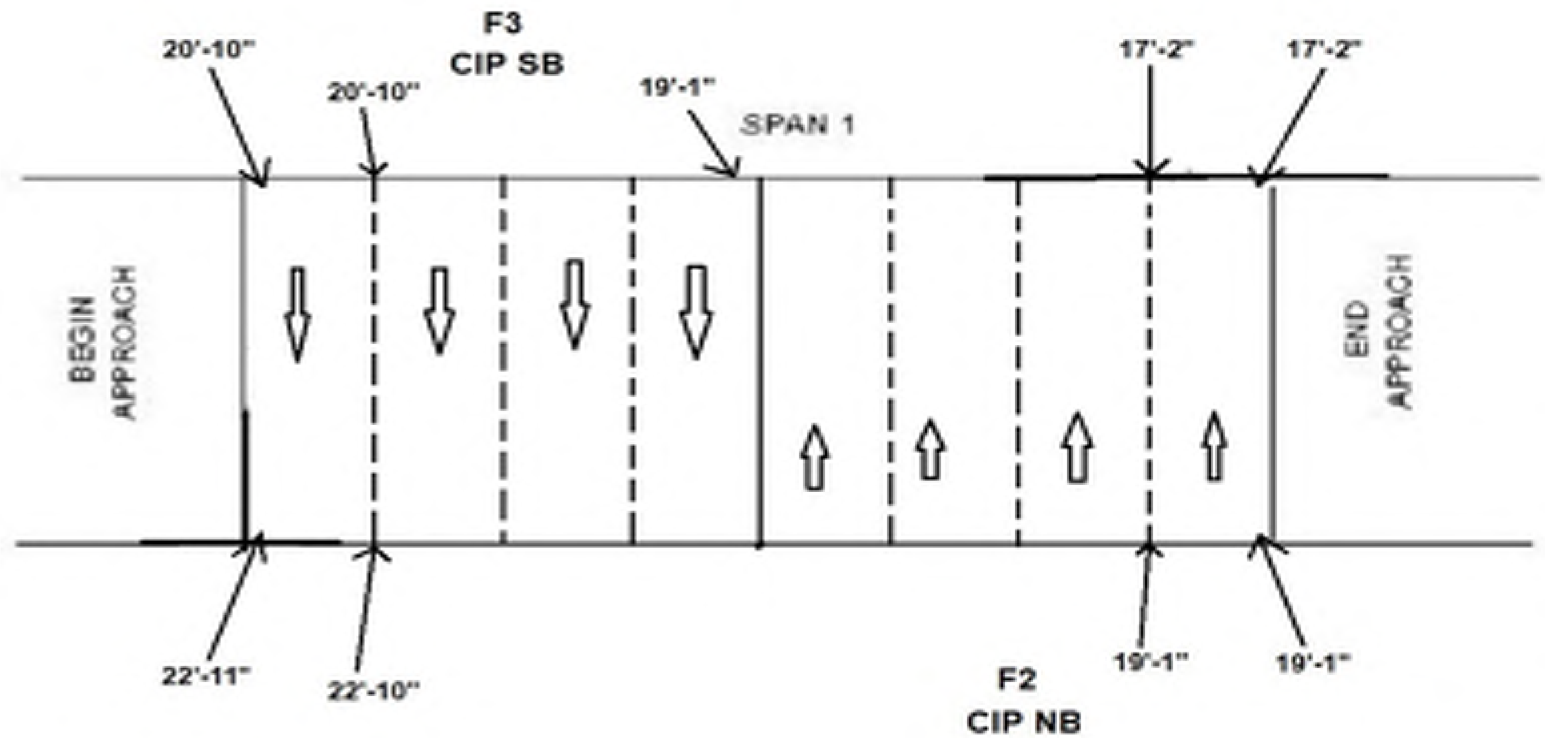
VERTICAL CLEARANCE
NTS

BIN 1065149


SPAN #15
(FEATURE F5)
15'-2"
14'-6"
MIN VC
22'-5"
21'-10"
21'-3"
PIER 14
END ABUTMENT
VERTICAL CLEARANCE
NTS
BIN 1065149

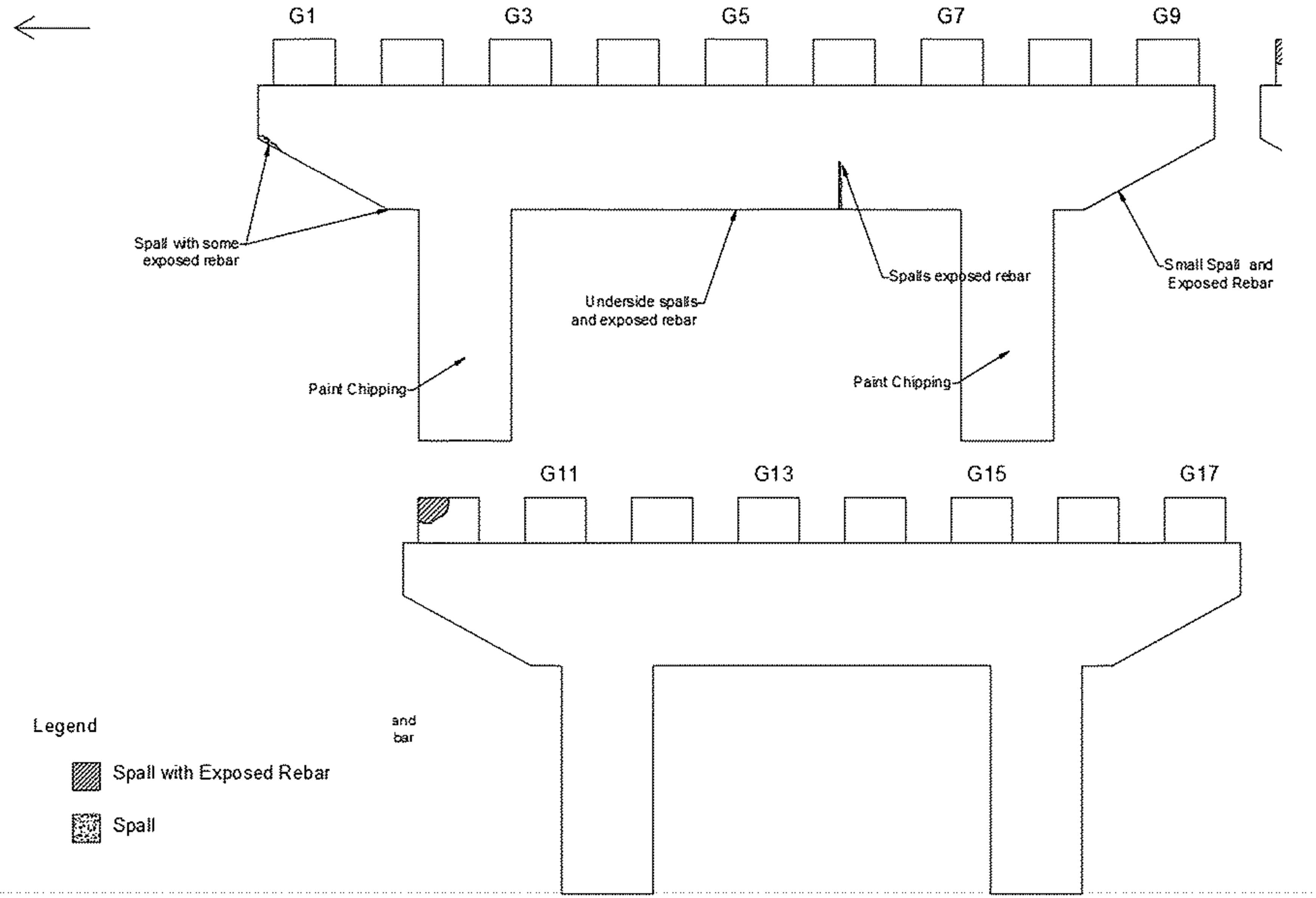
Ramp H

VERTICAL CLEARANCE



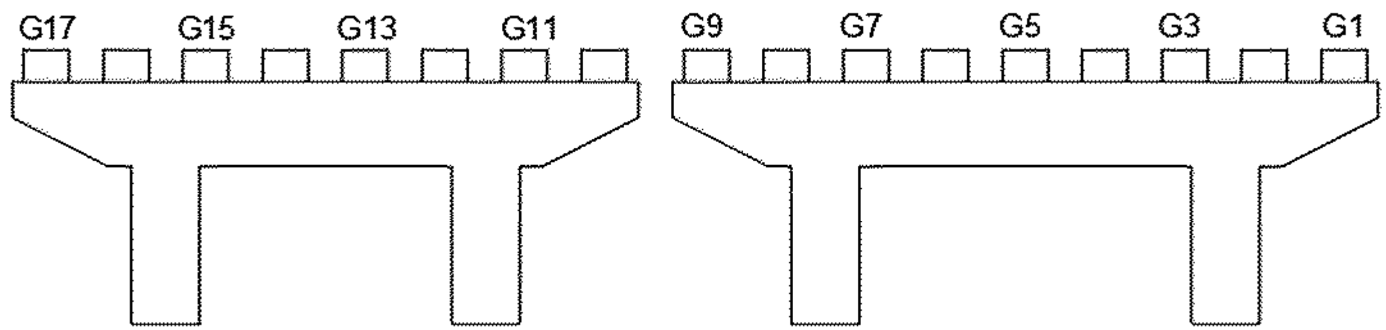
PIER CONDITION

Pier 1 (Span One Side)

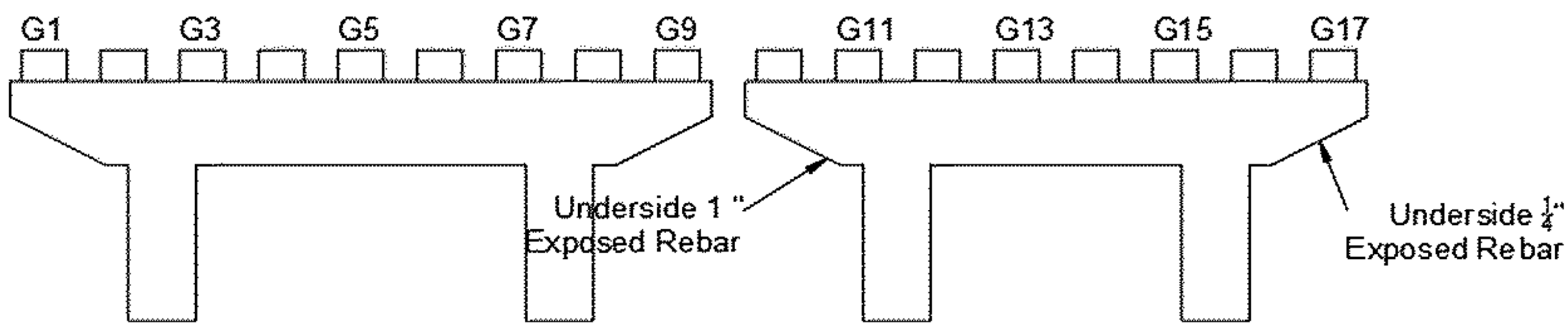


Pier 2

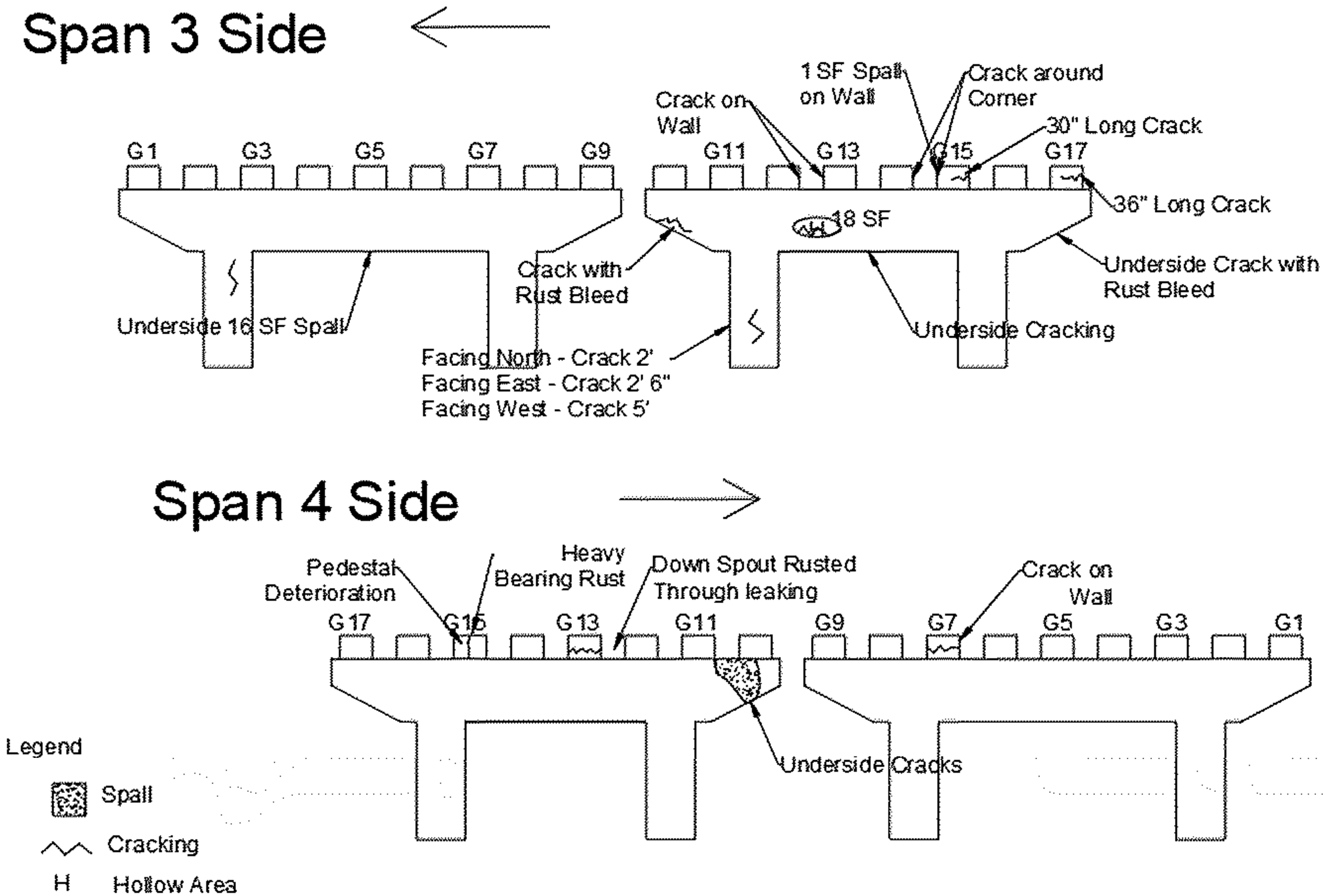
Span 3 Side



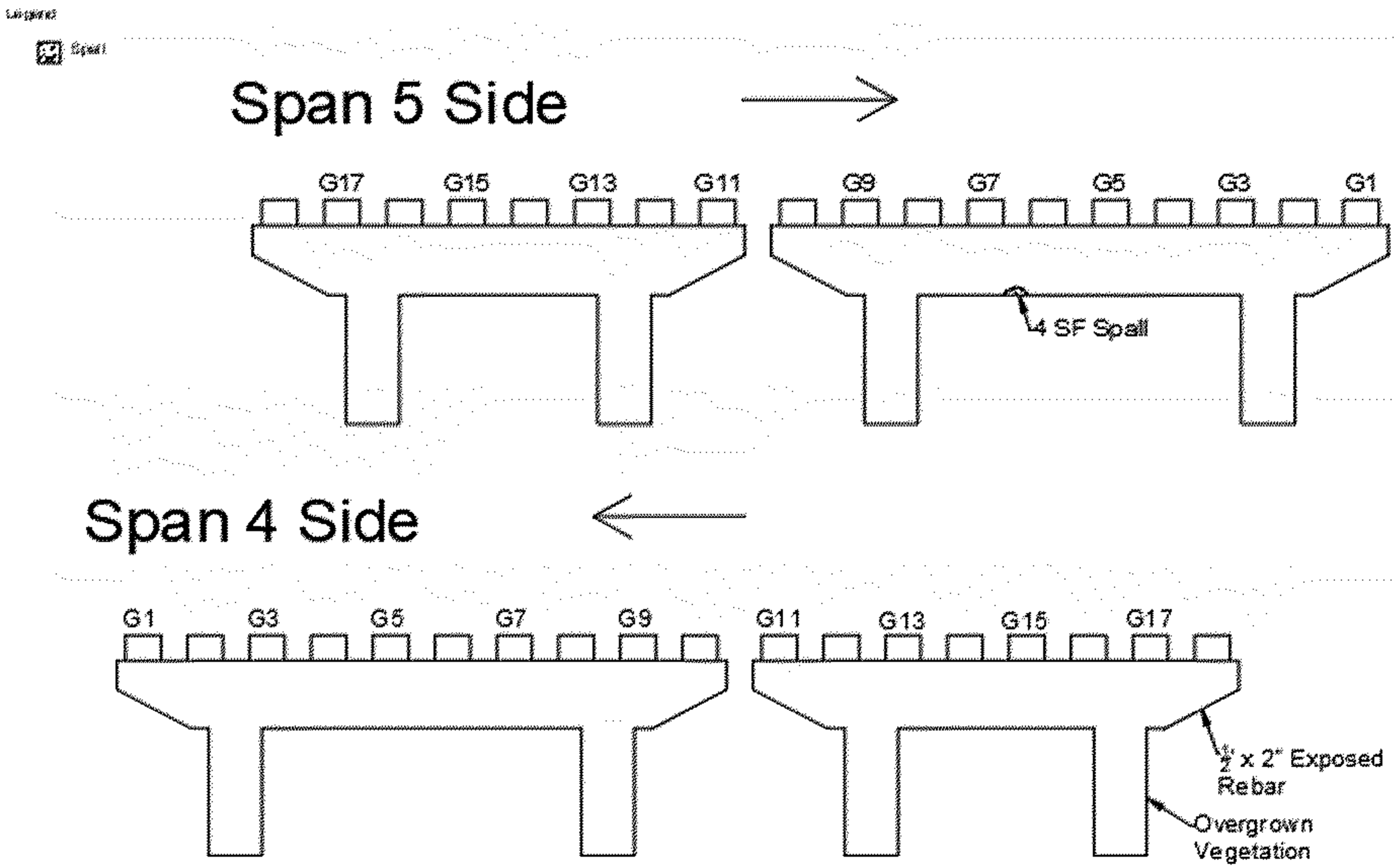
Span 2 Side



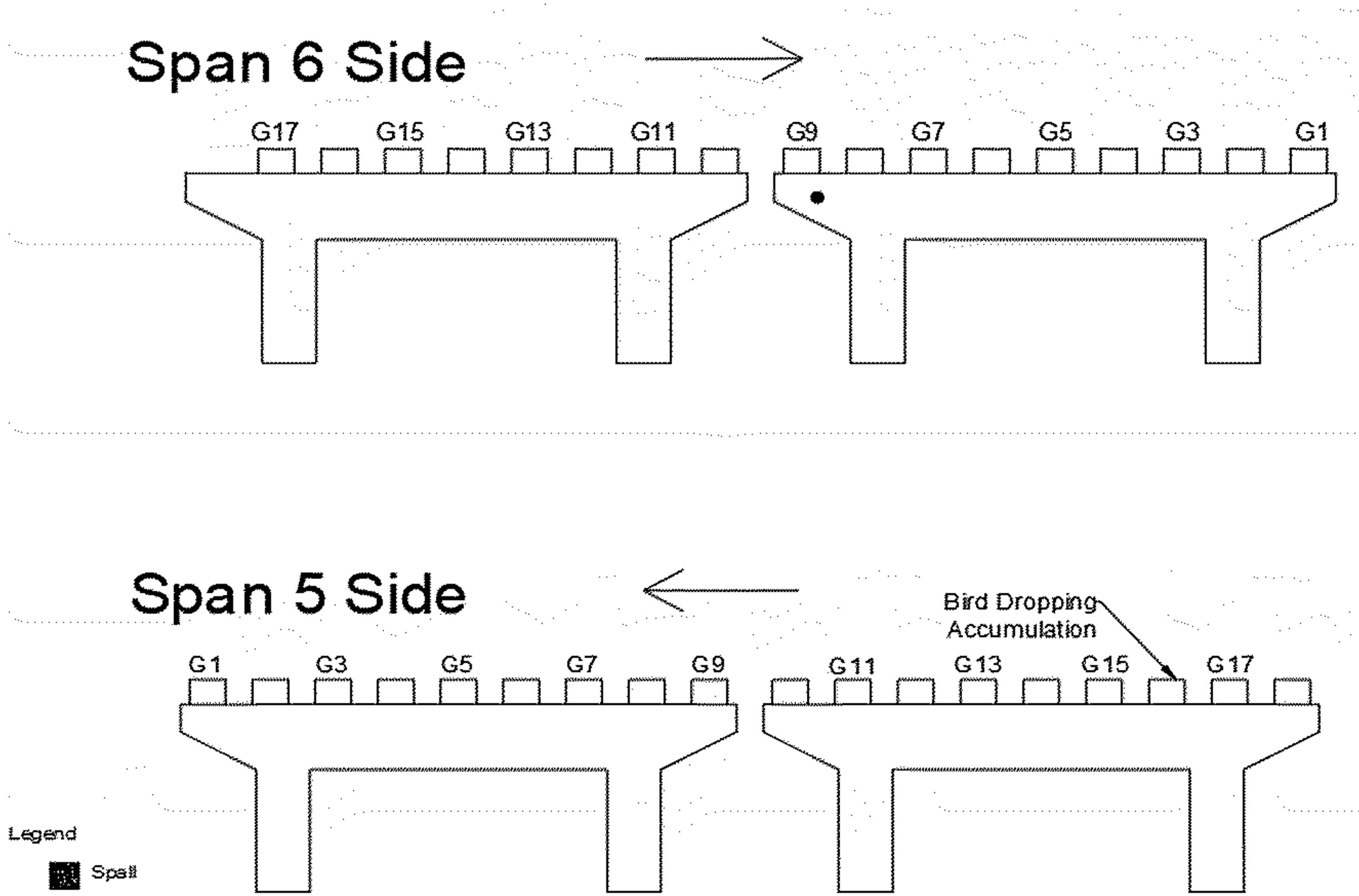
Pier 3


Span 3 Side
1 SF Spall on Wall
Crack around Corner
Crack on Wall
30" Long Crack
G1
G3
G5
G7
G9
G11
G13
G15
G17
36" Long Crack
18 SF
Crack with Rust Bleed
Underside Crack with Rust Bleed
Underside 16 SF Spall
Underside Cracking
Facing North - Crack 2'
Facing East - Crack 2' 6"
Facing West - Crack 5'
Span 4 Side
Heavy Bearing Rust
Pedestal Deterioration
Down Spout Rusted Through leaking
Crack on Wall
G17
G15
G13
G11
G9
G7
G5
G3
G1
Underside Cracks
Legend
Spall
Cracking
H Hollow Area

Pier 4


Span 5 Side
G17 G15 G13 G11 G9 G7 G5 G3 G1
4 SF Spall
Span 4 Side
G1 G3 G5 G7 G9 G11 G13 G15 G17
½" x 2" Exposed Rebar
Overgrown Vegetation

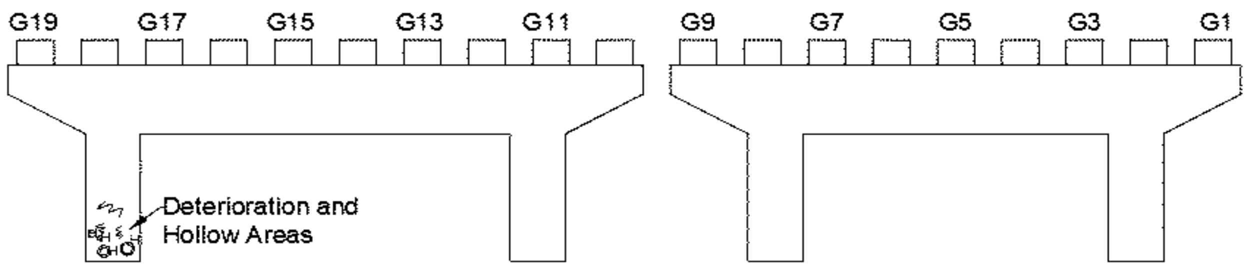
Pier 5



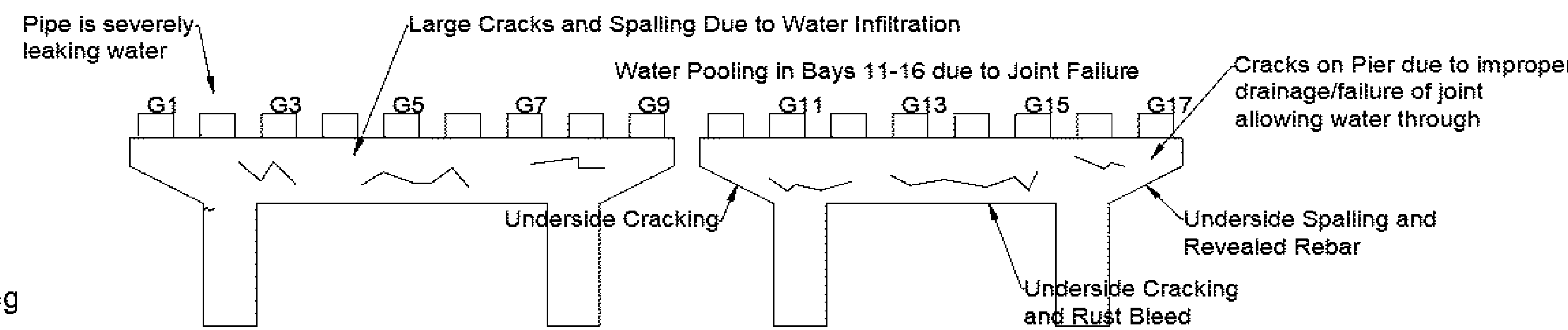
Span 6 Side
G17
G15
G13
G11
G9
G7
G5
G3
G1
Span 5 Side
G1
G3
G5
G7
G9
G11
G13
G15
G17
Bird Dropping Accumulation
Legend
Spall

Pier 6

Span 7 Side



Span 6 Side



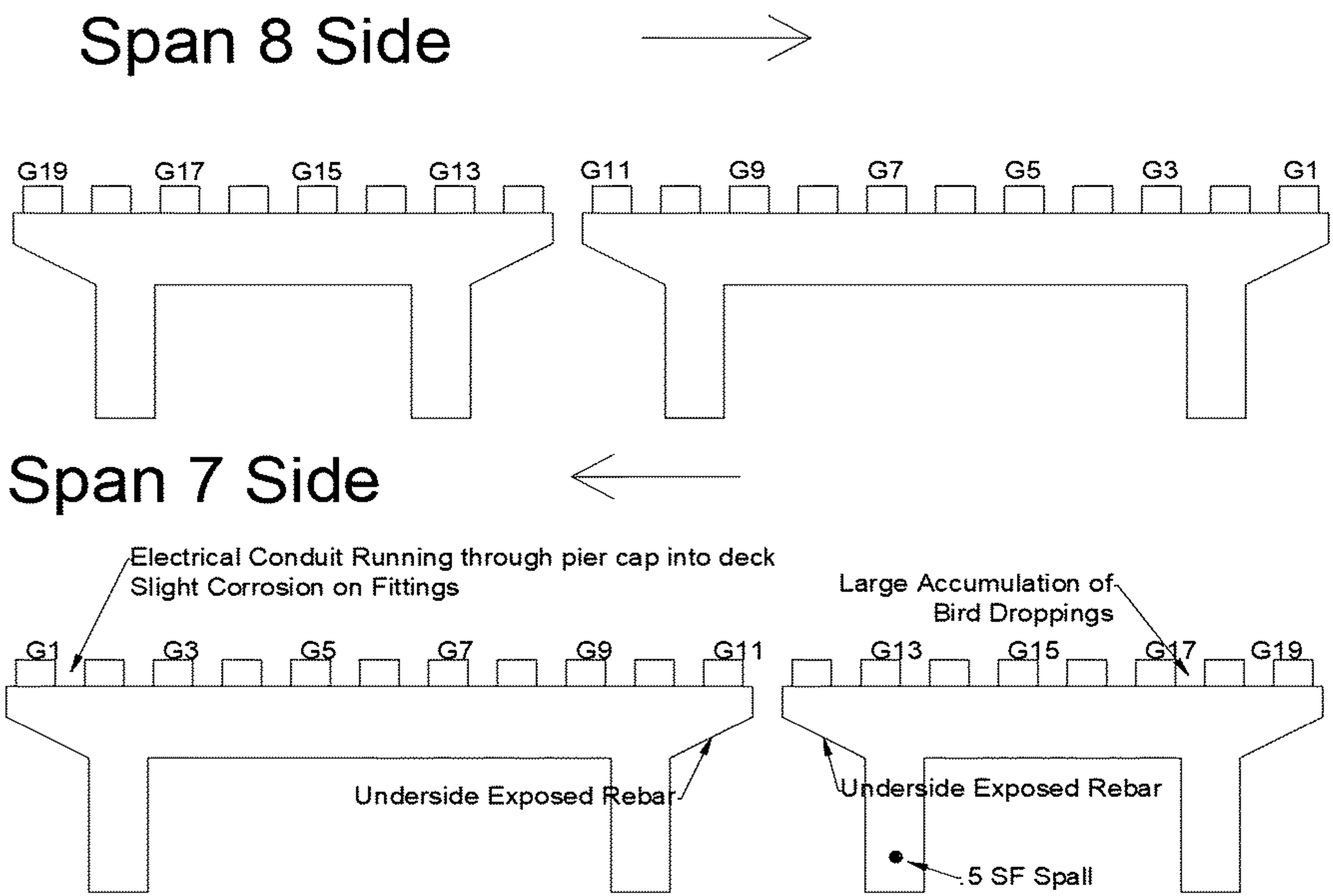
Legend

Cracking

H Hollow Area

Map Cracking

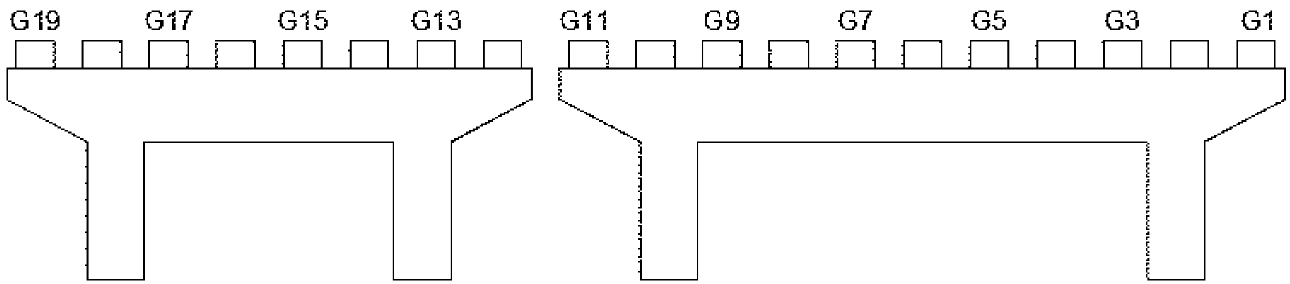
Pier 7



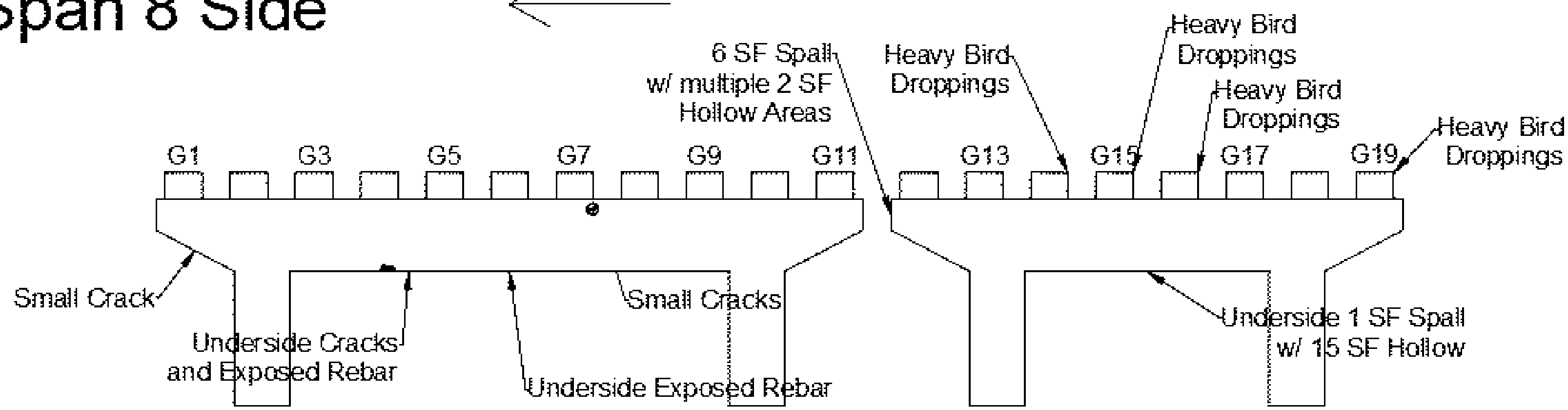
Span 8 Side
G19
G17
G15
G13
G11
G9
G7
G5
G3
G1
Span 7 Side
Electrical Conduit Running through pier cap into deck
Slight Corrosion on Fittings
Large Accumulation of
Bird Droppings
G1
G3
G5
G7
G9
G11
G13
G15
G17
G19
Underside Exposed Rebar
Underside Exposed Rebar
.5 SF Spall

Pier 8

Span 9 Side



Span 8 Side

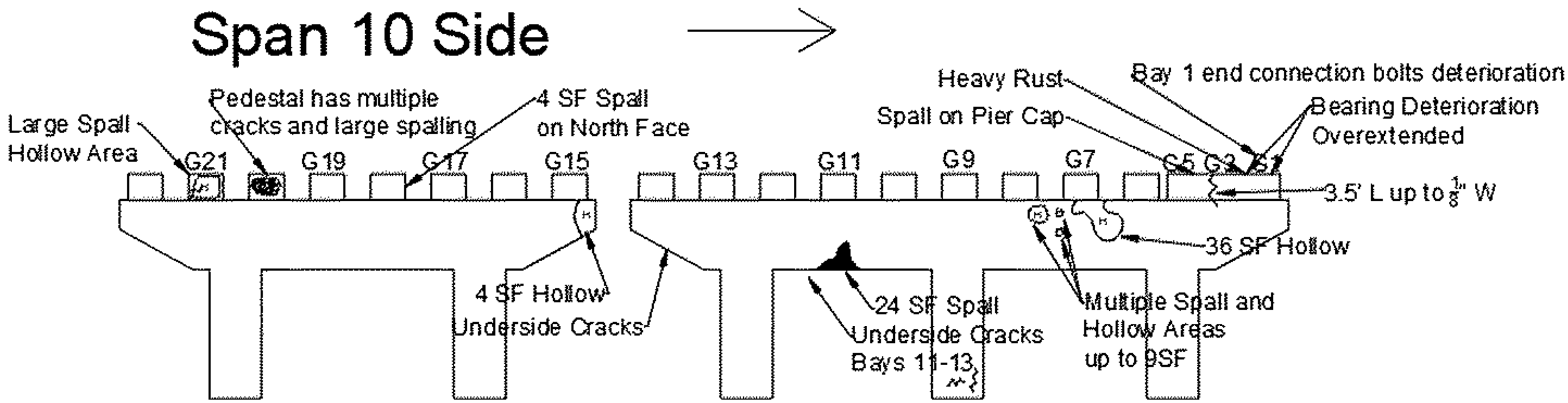


Legend

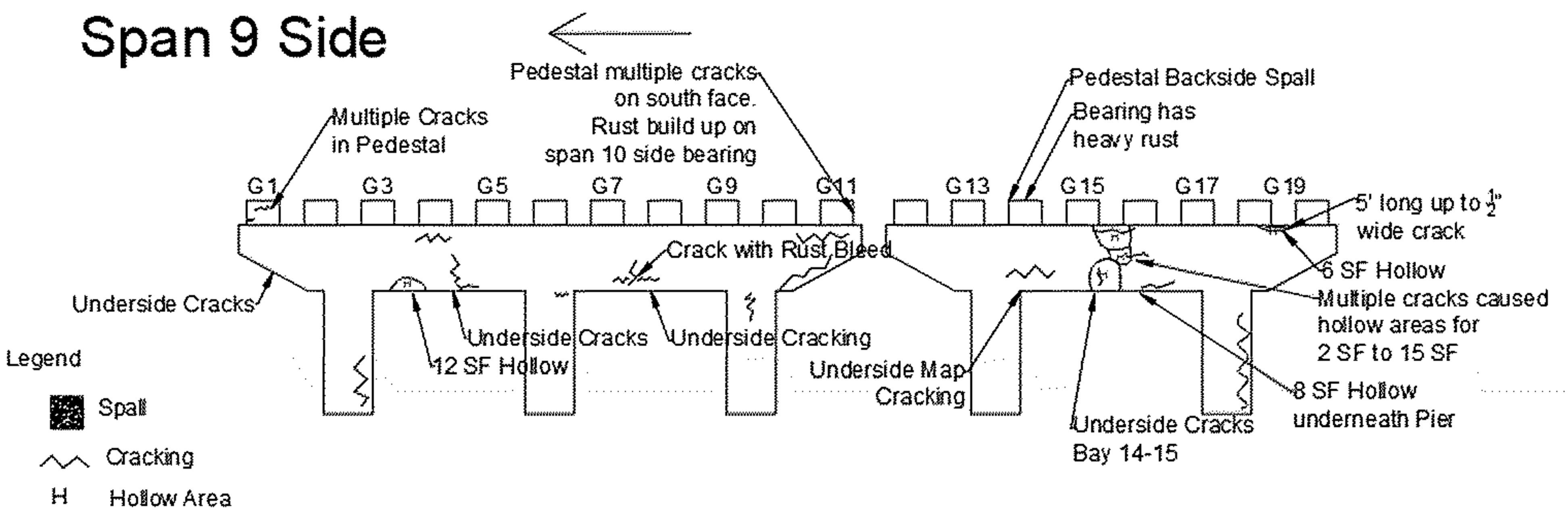
Spall

Pier 9

Span 10 Side

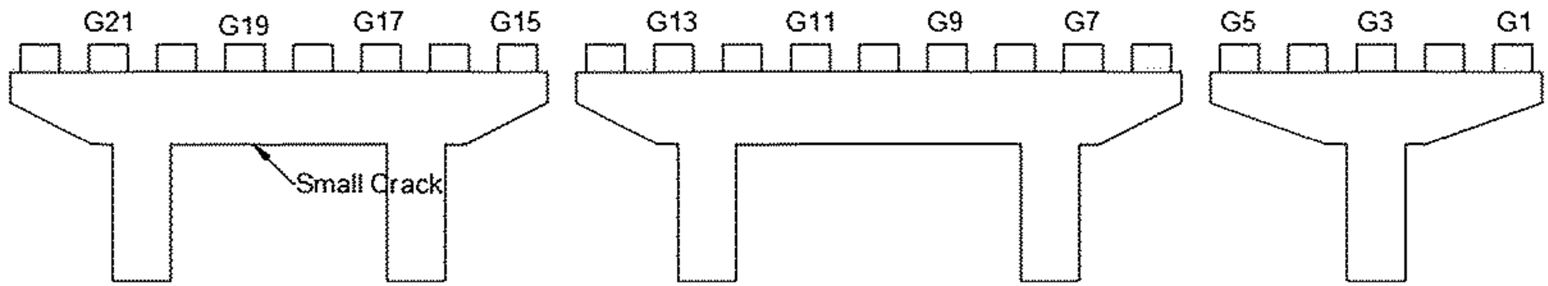


Span 9 Side

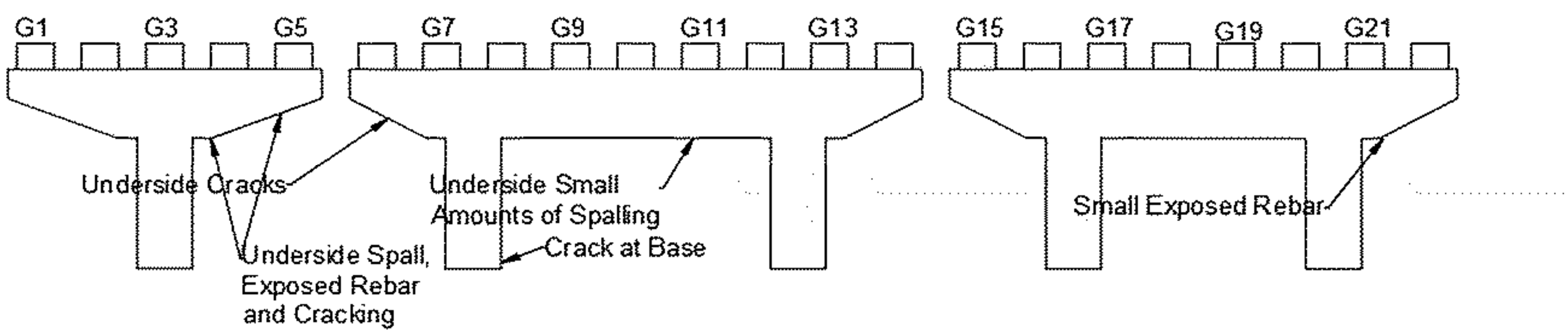


Pier 10

Span 11 Side

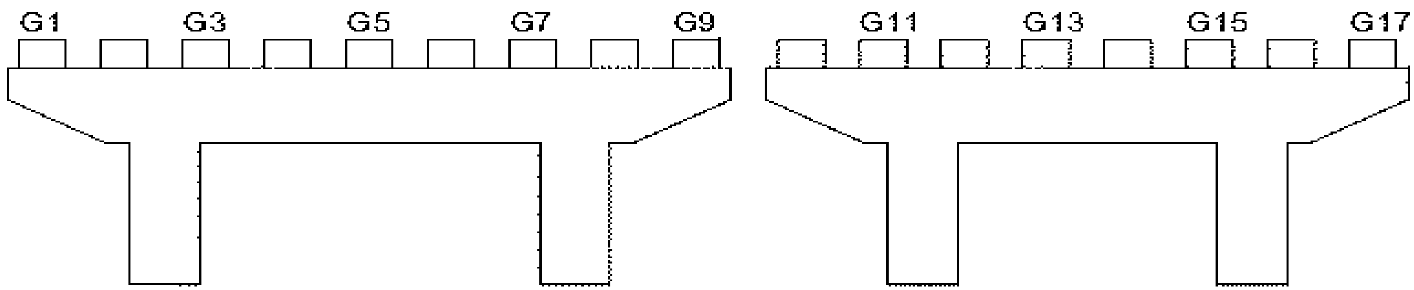


Span 10 Side

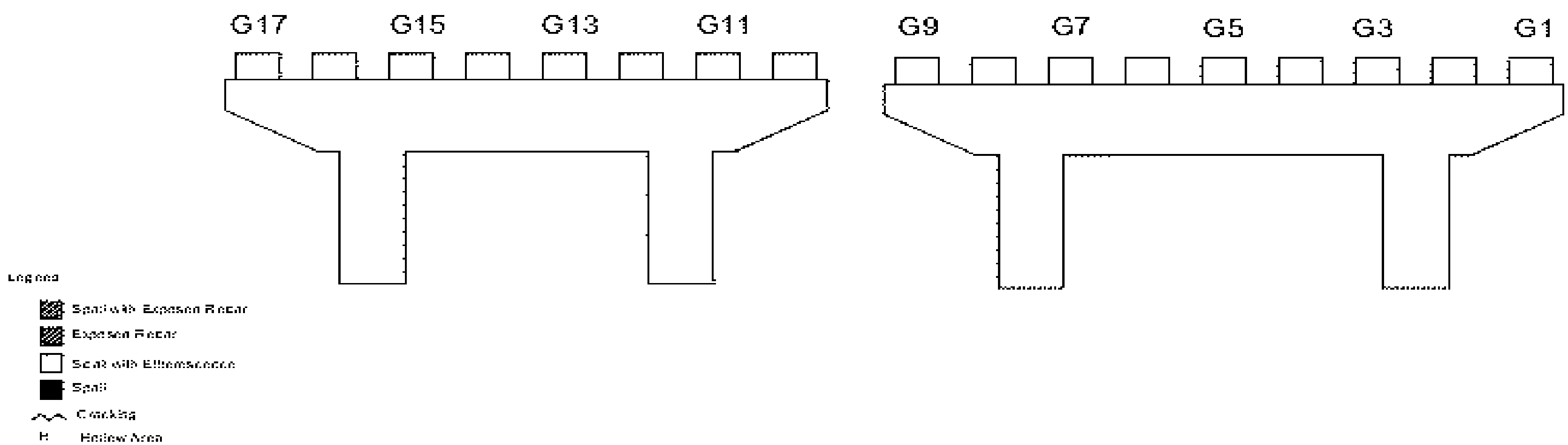


Pier 11

Span 11 Side

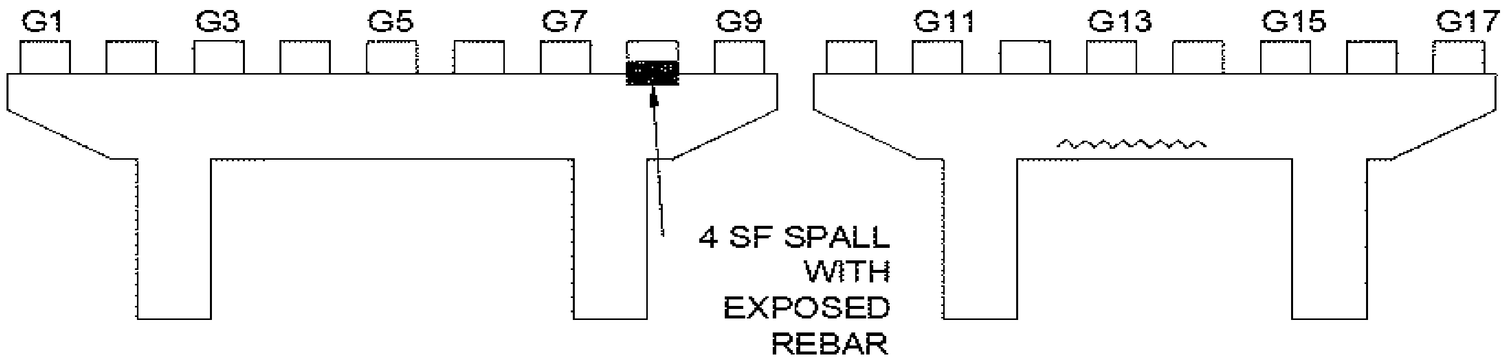


Span 12 Side

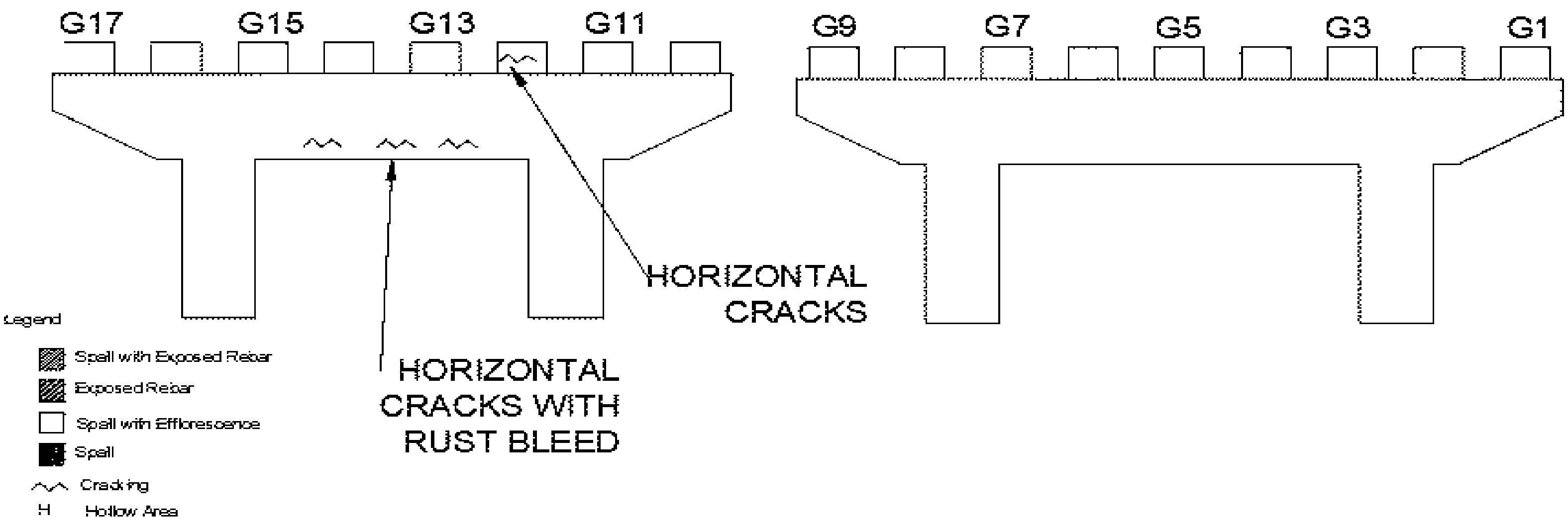


Pier 12

Span 12 Side

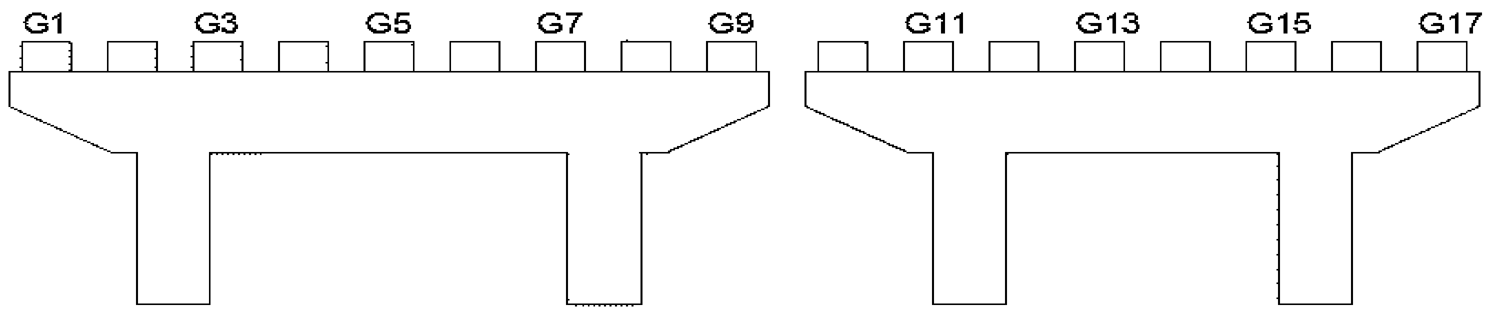


Span 13 Side

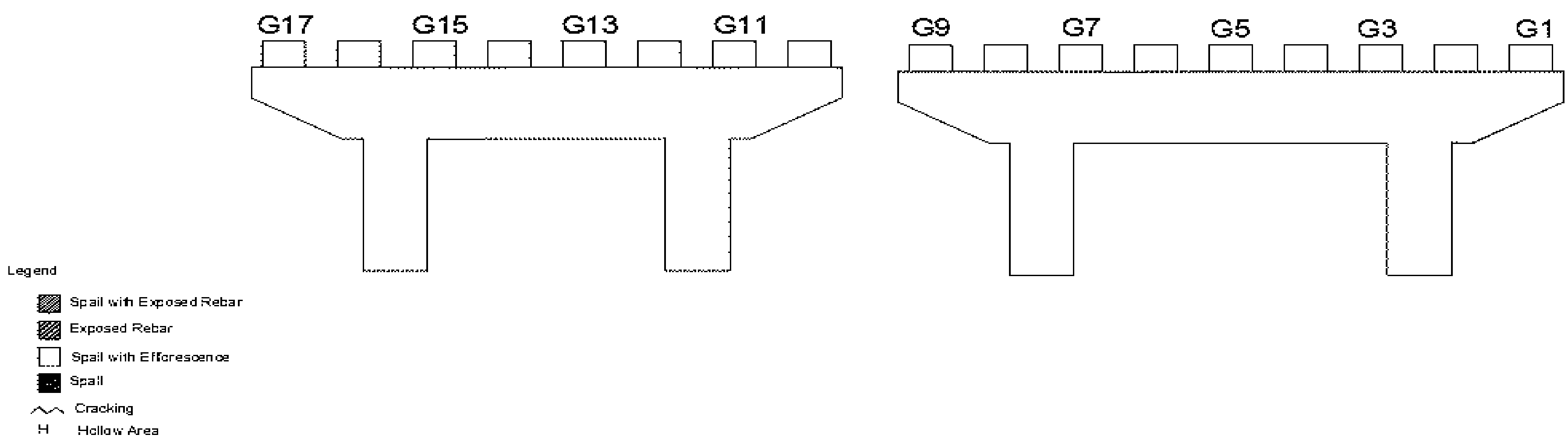


Pier 13

Span 13 Side

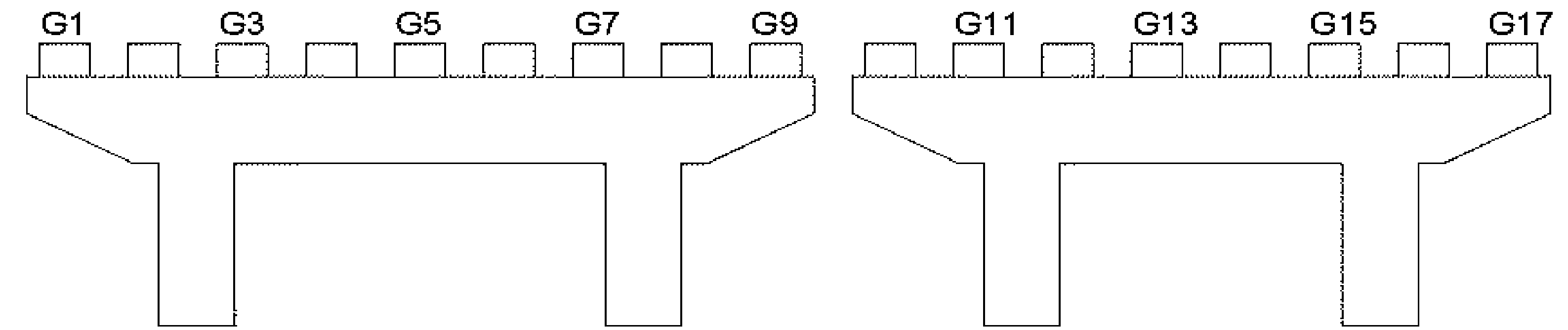


Span 14 Side

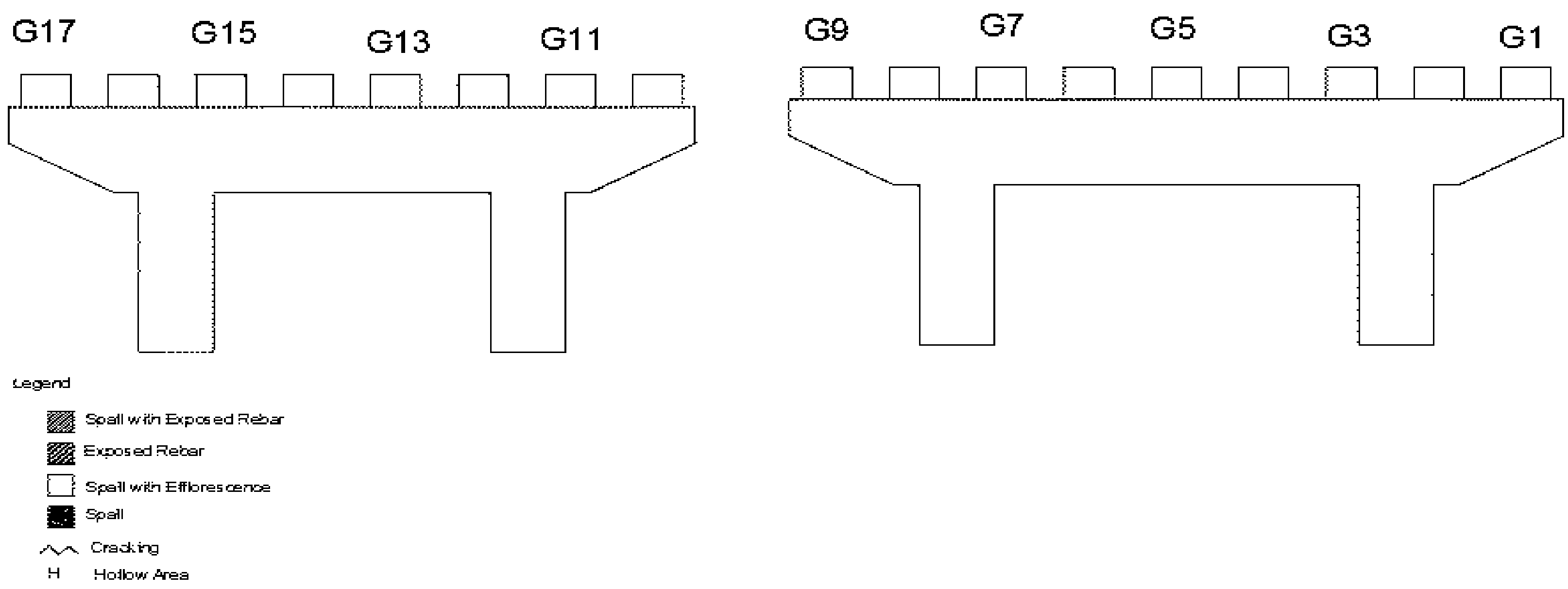


Pier 14

Span 14 Side



Span 15 Side



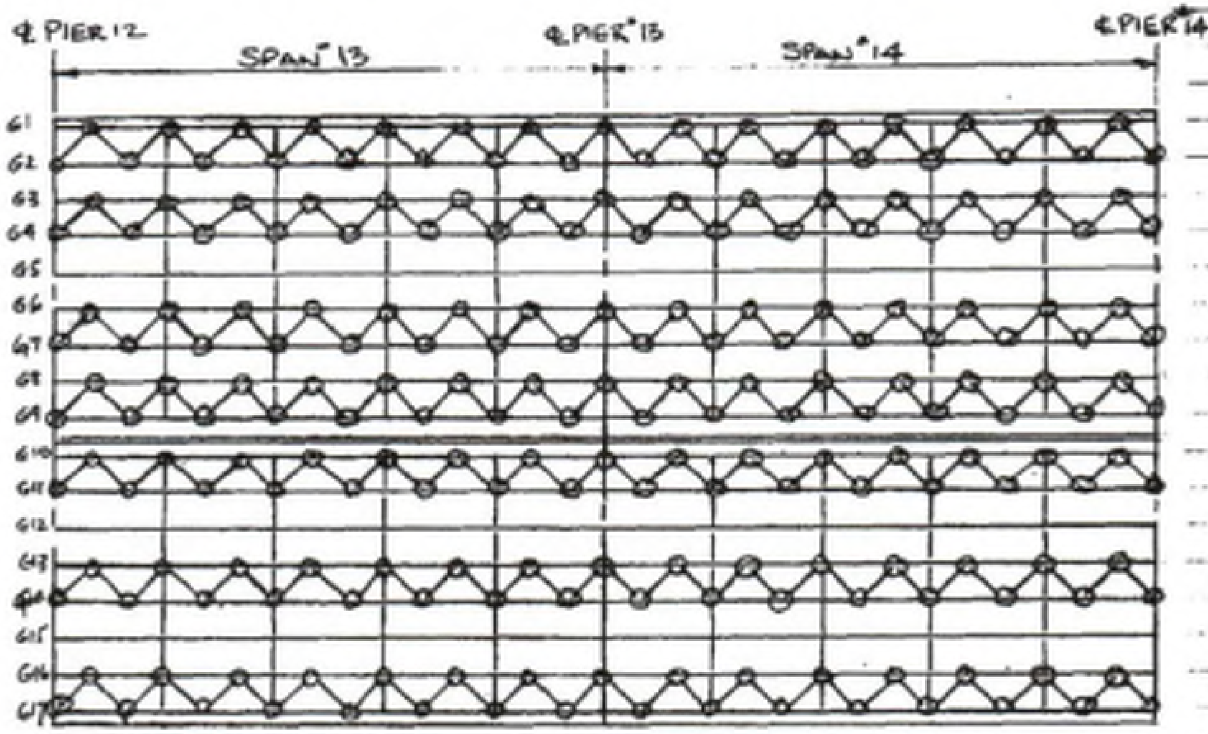
SPECIAL EMPHASIS SKETCH

BIN:1065149

DATE: July 2021

SPECIAL EMPHASIS

NORTH



FRAMING PLAN

NTS

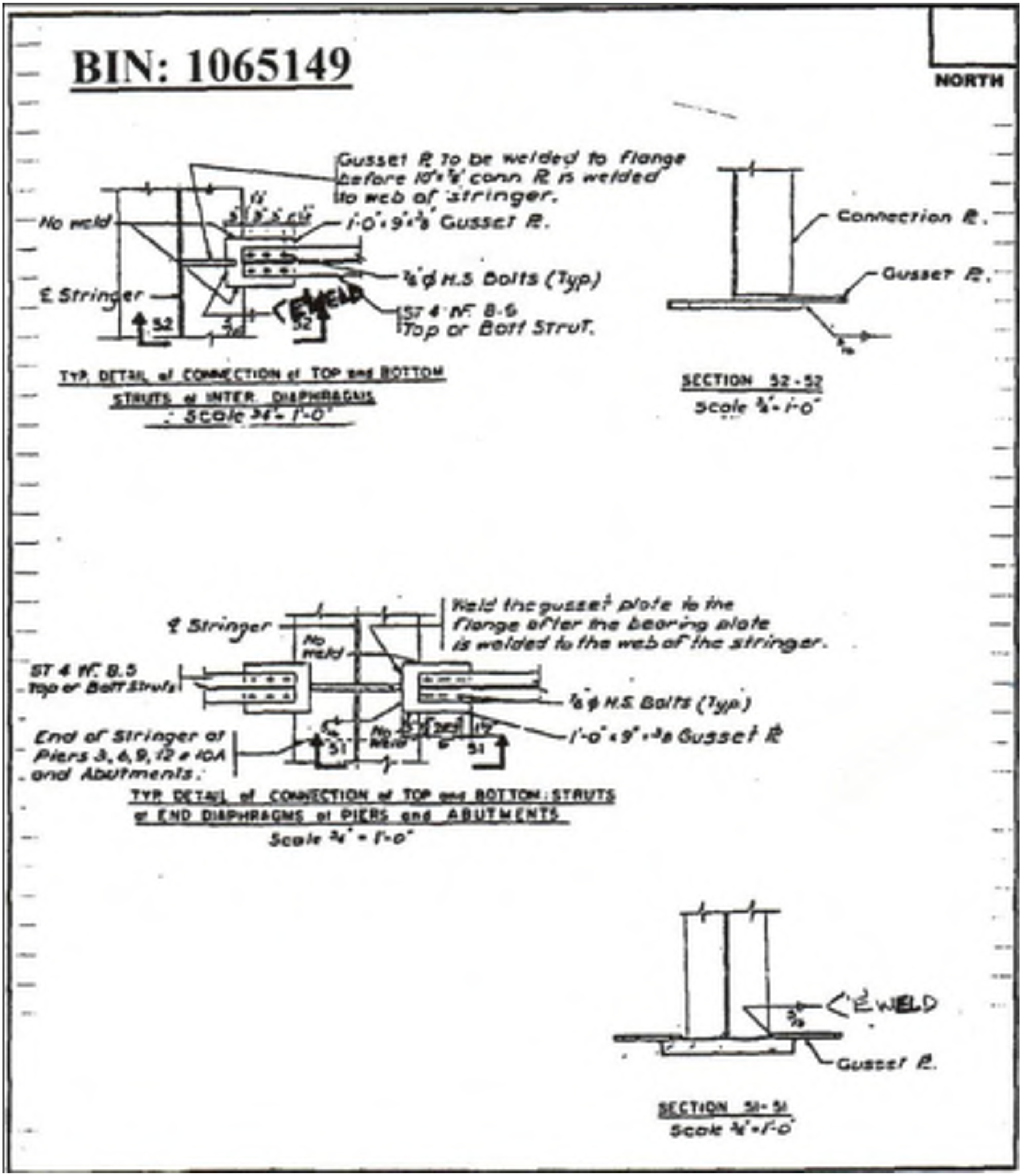
LEGEND

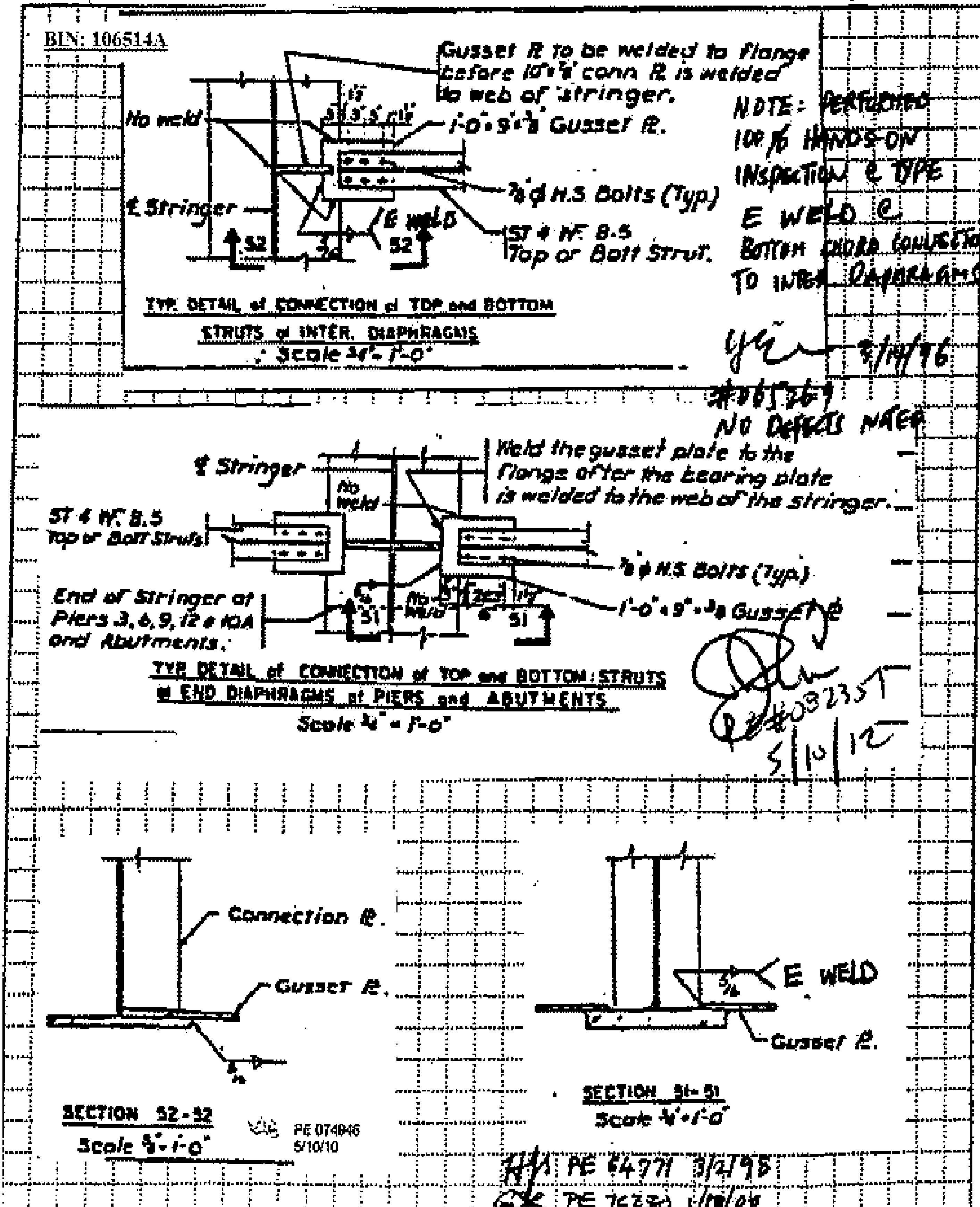
O - LOCATIONS OF CRITICAL E' WELD ON ALL GUSSET PLATES OF LATERAL BRACING, TO BOT. FLANGE OF GIRDERS.

[TYP FOR ALL SPANS (1 TO 15)]

BIN: 1065149

BIN:1065149
DATE: July 2021




BIN: 106514A
Gusset Ꝑ to be welded to flange before 10"x⅜" conn Ꝑ is welded to web of stringer.
No weld
1'-0"x 9"x⅜ Gusset Ꝑ.
⅞"ϕ H.S. Bolts (Typ)
℄ Stringer
E weld
52
52
ST 4 WF 8.5 Top or Bott Strut.
TYP. DETAIL of CONNECTION of TOP and BOTTOM STRUTS of INTER. DIAPHRAGMS
Scale ¾"= 1'-0"
NOTE: PERFORMED 100% HANDS-ON INSPECTION @ TYPE E WELD @ BOTTOM CHORD CONNECTION TO INTER. DIAPHRAGMS
9/14/96
NO DEFECTS NOTED
℄ Stringer
No weld
Weld the gusset plate to the flange after the bearing plate is welded to the web of the stringer.
ST 4 WF 8.5 Top or Bott Struts
⅞"ϕ H.S. Bolts (Typ.)
End of Stringer at Piers 3, 6, 9, 12 & 10A and Abutments.
No weld
1'-0"x 9"x⅜ Gusset Ꝑ
51
51
TYP. DETAIL of CONNECTION of TOP and BOTTOM STRUTS of END DIAPHRAGMS at PIERS and ABUTMENTS
Scale ¾" = 1'-0"
5/10/12
Connection Ꝑ.
Gusset Ꝑ.
SECTION 52-52
Scale ¾"= 1'-0"
PE 074946
5/10/10
E WELD
Gusset Ꝑ.
SECTION 51-51
Scale ¾"= 1'-0"
PE 64771 3/2/95
PE 76230 6/18/04

APPENDIX B

LATEST BIENNIAL INSPECTION REPORT

REPORTING PROCEDURE

Condition State	Condition Type	Type General Condition Guideline
CS-1	Good	That portion of the element that has either no deterioration or the deterioration is insignificant to the management of the element, meaning that portion of the element has no condition based preventive maintenance needs or repairs. Areas of an element that have received long lasting structural repairs that restore the full capacity of the element with an expected life equal to the original element may be coded as good condition.
CS-2	Fair	That portion of the element that has minor deficiencies that signify a progression of the deterioration process. This portion of the element may need condition based preventive maintenance. Areas of the element that have received repairs that improve the element, but the repair is not considered equal to the original member may be coded as fair.
CS-3	Poor	That portion of the element that has advanced deterioration but does not warrant structural review. This portion of the element may need condition based preventative maintenance or other remedial action.
CS-4	Severe	That portion of the element that warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge; OR a condition where that portion of the element is no longer effective for its intended purpose.
CS-5	Unknown	That portion of the element not assessable due to lack of access.

New York State Department of Transportation
General Bridge Inspection Report

Inspection Date: May 15, 2020

Structure Information

BIN: **1065149**

Feature Carried: 907M907MX5M14134

Feature Crossed: 907A907AX5M21126

Orientation: 1 - NORTH

Region: 11 - NEW YORK CITY

County: QUEENS

Political Unit: City of NEW YORK

Approximate Year Built: 1972

Primary Owner: New York State Department of Transportation

Primary Maintenance Responsibility: 12 - State - Subcontracted to another Party

General Type Main Span: 4 - Steel (Continuous), 02 - Stringer/Multi-Beam or Girder

This Bridge is not a Ramp

Number of Spans: 15

Postings

Posted Load Matches Inventory: Yes

Posted Load in field: Not Posted

Posted Vertical Clearances Match Inventory: Yes

Inventory On: Not Posted

Inventory Under: Not Posted

Number of Flags Issued

Red PIA: 0

Red: 0

Yellow: 0

Safety PIA: 0

New York State Inspection Overview

General Recommendation: 5

Federal NBI Ratings

NBI Deck Condition: 4

NBI Superstructure Condition: 7

NBI Substructure Condition: 5

NBI Channel Condition: N

NBI Culvert Condition: N

Action Items

Non-Structural Condition Observations noted: YES

Vulnerability Reviews Recommended: NO

Diving Inspection Requested: NO

Further Investigation Requested: NO

Inspector & Reviewer Signature Information

Inspection Signature:	Steven Wallin, P.E. 089720-1	*Date:* July 14, 2020
Review Signature:	Luis Monroe, P.E. 078639-1	*Date:* July 14, 2020
Processed by :	Johnbull Bello	*Date:* July 20, 2020

Report Printed: July 20, 2020 10:50:39 AM

Special Emphasis Inspection

Special Emphasis Detail	"Other" Special Emphasis Detail Description	Hands-On Insp Performed	Hands-On Inspection Note
AASHTO Category D, E, and E' welded details		Yes	100% Hands-On Inspection was performed on all Fatigue Prone Category E' welds at the gusset plate connections to girder bottom flanges in all spans. (Photos 2 & 3) Ref. Special Emphasis Sketches.

Additional Information

Overloads Observed

No overload vehicles observed during this inspection.

Notes to Next Inspector

For Access to Spans 1-4 with a 30' Bucket Truck, drive over grade from the left side of the exit ramp (Exit 23) of the Grand Central Parkway Eastbound.

Improvements Observed

2018: Curbs along the median have been repaired.

2020: At Pier 3, the end face of Pedestal #15 which was spall has been repaired. (Photo 27)

Pedestrian Fence Height

None

Snow Fence

None

Bin Plate Condition

OK

Scour Critical Rating

N - Bridge not over waterway.

Field Notes

Staff Present During Inspection		
Name	**Title**	**Organization**
Bryant Yi	ATL	Stantec
Kevin Maier	ATL	Stantec
Steven Wallin	TL	Stantec

General Equipment Required for Inspection*
Access Type
13 - Walking
15 - Extension Ladder
19 - Up to 30 Foot Lift
20 - 30 to 90 Foot Lift
29 - Lane Closure With Shadow Vehicle

*** For span specific equipment requirements refer to the Active Inventory's "Access Needs" tab in BDIS.**

Detailed Time & Weather Conditions				
Field Date	**Arrival**	**Departure**	**Temp (F)**	**Weather Conditions**
04/20/2020	09:00 AM	03:00 PM	45	Cloudy
04/22/2020	09:00 AM	03:00 PM	43	Partly Cloudy
04/23/2020	09:00 AM	01:00 PM	40	Cloudy
04/30/2020	09:00 AM	03:00 PM	52	Light Rain
05/12/2020	11:00 AM	03:00 PM	53	Sunny
05/15/2020	09:00 AM	03:00 PM	65	Sunny

Inspection Times (hours)	
Time required for travel, inspection and report preparation	58
Lane closure usage	18
Railroad flagging time	No

Element Quantities

Element Assessment Summary Table

Element	Total Quantity	Unit	CS-1	CS-2	CS-3	CS-4	CS-5
12 - Reinforced Concrete Deck	242124	ft^2	88940	152252	932		0
107 - Steel Open Girder/Beam	33433	ft	31683	1750			0
205 - Reinforced Concrete Column	54	each	50	4			0
210 - Reinforced Concrete Pier Wall	72	ft	72				0
215 - Reinforced Concrete Abutment	256	ft	50	200	6		0
220 - Reinforced Concrete Pile Cap/Footing	2560	ft					2560
234 - Reinforced Concrete Pier Cap	1824	ft	1238	445	141		0
305 - Assembly Joint without Seal	512	ft		494	18		0
311 - Movable Bearing	269	each	96	141	32		0
313 - Fixed Bearing	93	each	71	22			0
321 - Reinforced Concrete Approach Slab	13461	ft^2	6025	7420	16		0
330 - Metal Bridge Railing	5697	ft	4204	1426	67		0
510 - Wearing Surfaces	227030	ft^2	106289	119521	1220		0
515 - Steel Protective Coating	518296	ft^2	468700	48955	629	12	0
800 - Erosion or Scour	3774	ft	3374	400			0
811 - Curb	7596	ft	3798	3798			0
830 - Secondary Members	15	each	14	1			0
831 - Steel Beam End	153	each	52	101			0
850 - Backwall	256	ft		252	4		0
851 - Abutment Pedestal	34	each	15	19			0
852 - Pier Pedestal	328	each	125	180	23		0
853 - Wingwall	480	ft		480			0

Element Assessment by Span

Element**	Total Quantity	Unit	CS-1	CS-2	CS-3	CS-4	CS-5
Span Number : 1							
BA215 - Reinforced Concrete Abutment	128	ft	50	75	3		0
BA220 - Reinforced Concrete Pile Cap/Footing	130	ft					130
BA311 - Movable Bearing	17	each	16		1		0
515 - Steel Protective Coating	34	ft^2	32			2	0
BA321 - Reinforced Concrete Approach Slab	6025	ft^2	6025				0
BA800 - Erosion or Scour	130	ft	125	5			0
BA850 - Backwall	128	ft		126	2		0

Element**	Total Quantity	Unit	CS-1	CS-2	CS-3	CS-4	CS-5
BA851 - Abutment Pedestal	17	each	15	2			0
BW220 - Reinforced Concrete Pile Cap/Footing	240	ft					240
BW800 - Erosion or Scour	240	ft	240				0
BW853 - Wingwall	240	ft		240			0
PR205 - Reinforced Concrete Column	4	each	4				0
PR220 - Reinforced Concrete Pile Cap/Footing	130	ft					130
PR234 - Reinforced Concrete Pier Cap	128	ft	128				0
PR313 - Fixed Bearing	17	each	17				0
515 - Steel Protective Coating	34	ft^2	34				0
PR800 - Erosion or Scour	216	ft	216				0
PR852 - Pier Pedestal	17	each		16	1		0
12 - Reinforced Concrete Deck	13440	ft^2	5219	8027	194		0
510 - Wearing Surfaces	12390	ft^2		12290	100		0
107 - Steel Open Girder/Beam	1785	ft	1606	179			0
515 - Steel Protective Coating	26632	ft^2	23969	2663			0
330 - Metal Bridge Railing	315	ft	236	79			0
515 - Steel Protective Coating	705	ft^2	529	176			0
811 - Curb	420	ft	210	210			0
830 - Secondary Members	1	each	1				0
Span Number : 2							
PR205 - Reinforced Concrete Column	4	each	4				0
PR220 - Reinforced Concrete Pile Cap/Footing	130	ft					130
PR234 - Reinforced Concrete Pier Cap	128	ft	128				0
PR311 - Movable Bearing	17	each	17				0
515 - Steel Protective Coating	34	ft^2	34				0
PR800 - Erosion or Scour	216	ft	216				0
PR852 - Pier Pedestal	17	each	17				0
12 - Reinforced Concrete Deck	19072	ft^2	5862	13020	190		0
510 - Wearing Surfaces	17582	ft^2	7482	10000	100		0
107 - Steel Open Girder/Beam	2533	ft	2280	253			0
515 - Steel Protective Coating	37792	ft^2	34013	3779			0
330 - Metal Bridge Railing	447	ft	317	112	18		0
515 - Steel Protective Coating	447	ft^2	336	111			0
811 - Curb	596	ft	298	298			0
830 - Secondary Members	1	each	1				0
Span Number : 3							
PR205 - Reinforced Concrete Column	4	each	4				0

Element**	Total Quantity	Unit	CS-1	CS-2	CS-3	CS-4	CS-5
PR220 - Reinforced Concrete Pile Cap/Footing	130	ft					130
PR234 - Reinforced Concrete Pier Cap	128	ft		77	51		0
PR305 - Assembly Joint without Seal	128	ft		120	8		0
PR311 - Movable Bearing	35	each	10	25			0
515 - Steel Protective Coating	70	ft^2	20	50			0
PR800 - Erosion or Scour	216	ft	216				0
PR831 - Steel Beam End	17	each		17			0
PR852 - Pier Pedestal	35	each		31	4		0
12 - Reinforced Concrete Deck	13440	ft^2	5506	7887	47		0
510 - Wearing Surfaces	12390	ft^2	6240	6000	150		0
107 - Steel Open Girder/Beam	1785	ft	1606	179			0
515 - Steel Protective Coating	26632	ft^2	23969	2663			0
330 - Metal Bridge Railing	315	ft	222	79	14		0
515 - Steel Protective Coating	705	ft^2	529	176			0
811 - Curb	420	ft	210	210			0
830 - Secondary Members	1	each	1				0
Span Number : 4							
PR205 - Reinforced Concrete Column	4	each	4				0
PR220 - Reinforced Concrete Pile Cap/Footing	130	ft					130
PR234 - Reinforced Concrete Pier Cap	128	ft		123	5		0
PR311 - Movable Bearing	18	each		18			0
515 - Steel Protective Coating	36	ft^2	36				0
PR800 - Erosion or Scour	216	ft	216				0
PR831 - Steel Beam End	18	each	18				0
PR852 - Pier Pedestal	18	each	18				0
12 - Reinforced Concrete Deck	14336	ft^2	4151	10153	32		0
510 - Wearing Surfaces	13216	ft^2	6900	6216	100		0
107 - Steel Open Girder/Beam	2016	ft	2016				0
515 - Steel Protective Coating	30079	ft^2	27072	3007			0
330 - Metal Bridge Railing	336	ft	240	84	12		0
515 - Steel Protective Coating	751	ft^2	564	187			0
811 - Curb	448	ft	224	224			0
830 - Secondary Members	1	each	1				0
Span Number : 5							
PR205 - Reinforced Concrete Column	4	each	4				0
PR220 - Reinforced Concrete Pile Cap/Footing	130	ft					130
PR234 - Reinforced Concrete Pier Cap	128	ft	128				0

Element**	Total Quantity	Unit	CS-1	CS-2	CS-3	CS-4	CS-5
PR313 - Fixed Bearing	18	each	18				0
515 - Steel Protective Coating	36	ft²	36				0
PR800 - Erosion or Scour	216	ft	216				0
PR852 - Pier Pedestal	18	each	18				0
12 - Reinforced Concrete Deck	20256	ft²	6480	13684	92		0
510 - Wearing Surfaces	18644	ft²		18569	75		0
107 - Steel Open Girder/Beam	2844	ft	2844				0
515 - Steel Protective Coating	42432	ft²	42432				0
330 - Metal Bridge Railing	474	ft	355	119			0
515 - Steel Protective Coating	1055	ft²	792	263			0
811 - Curb	632	ft	316	316			0
830 - Secondary Members	1	each	1				0
Span Number : 6							
PR205 - Reinforced Concrete Column	4	each	4				0
PR220 - Reinforced Concrete Pile Cap/Footing	130	ft					130
PR234 - Reinforced Concrete Pier Cap	128	ft	101	20	7		0
PR305 - Assembly Joint without Seal	128	ft		128			0
PR311 - Movable Bearing	37	each		30	7		0
515 - Steel Protective Coating	74	ft²			74		0
PR800 - Erosion or Scour	216	ft	216				0
PR831 - Steel Beam End	18	each		18			0
PR852 - Pier Pedestal	37	each		33	4		0
12 - Reinforced Concrete Deck	14102	ft²	4992	9070	40		0
510 - Wearing Surfaces	12980	ft²	7000	5980			0
107 - Steel Open Girder/Beam	1980	ft	1782	198			0
515 - Steel Protective Coating	29542	ft²	23634	5908			0
330 - Metal Bridge Railing	330	ft	247	83			0
515 - Steel Protective Coating	738	ft²	554	184			0
811 - Curb	440	ft	220	220			0
830 - Secondary Members	1	each	1				0
Span Number : 7							
PR205 - Reinforced Concrete Column	4	each	4				0
PR220 - Reinforced Concrete Pile Cap/Footing	130	ft					130
PR234 - Reinforced Concrete Pier Cap	128	ft	128				0
PR311 - Movable Bearing	19	each	19				0
515 - Steel Protective Coating	38	ft²	38				0
PR800 - Erosion or Scour	216	ft	216				0

Element**	Total Quantity	Unit	CS-1	CS-2	CS-3	CS-4	CS-5
PR831 - Steel Beam End	19	each		19			0
PR852 - Pier Pedestal	19	each	19				0
12 - Reinforced Concrete Deck	14976	ft^2	7405	7544	27		0
510 - Wearing Surfaces	13806	ft^2	7440	6306	60		0
107 - Steel Open Girder/Beam	2223	ft	2223				0
515 - Steel Protective Coating	33167	ft^2	33167				0
330 - Metal Bridge Railing	351	ft	263	88			0
515 - Steel Protective Coating	784	ft^2	588	196			0
811 - Curb	468	ft	234	234			0
830 - Secondary Members	1	each	1				0
Span Number : 8							
PR205 - Reinforced Concrete Column	4	each	4				0
PR220 - Reinforced Concrete Pile Cap/Footing	130	ft					130
PR234 - Reinforced Concrete Pier Cap	128	ft	126		2		0
PR313 - Fixed Bearing	19	each	19				0
515 - Steel Protective Coating	38	ft^2	38				0
PR800 - Erosion or Scour	216	ft	216				0
PR852 - Pier Pedestal	19	each	19				0
12 - Reinforced Concrete Deck	19230	ft^2	5690	13510	30		0
510 - Wearing Surfaces	17700	ft^2	9650	8000	50		0
107 - Steel Open Girder/Beam	2850	ft	2850				0
515 - Steel Protective Coating	42522	ft^2	42522				0
330 - Metal Bridge Railing	450	ft	337	113			0
515 - Steel Protective Coating	1002	ft^2	752	250			0
811 - Curb	600	ft	300	300			0
830 - Secondary Members	1	each	1				0
Span Number : 9							
PR205 - Reinforced Concrete Column	5	each	5				0
PR220 - Reinforced Concrete Pile Cap/Footing	130	ft					130
PR234 - Reinforced Concrete Pier Cap	128	ft		98	30		0
PR305 - Assembly Joint without Seal	128	ft		128			0
PR311 - Movable Bearing	41	each		40	1		0
515 - Steel Protective Coating	82	ft^2		20	62		0
PR800 - Erosion or Scour	216	ft	216				0
PR831 - Steel Beam End	19	each		19			0
PR852 - Pier Pedestal	41	each		36	5		0
12 - Reinforced Concrete Deck	16520	ft^2	6365	10113	42		0

Element**	Total Quantity	Unit	CS-1	CS-2	CS-3	CS-4	CS-5
510 - Wearing Surfaces	15340	ft^2	8765	6500	75		0
107 - Steel Open Girder/Beam	2242	ft	2242				0
515 - Steel Protective Coating	33451	ft^2	33451				0
330 - Metal Bridge Railing	354	ft	257	89	8		0
515 - Steel Protective Coating	791	ft^2	594	197			0
811 - Curb	472	ft	236	236			0
830 - Secondary Members	1	each	1				0
Span Number : 10							
PR205 - Reinforced Concrete Column	5	each	5				0
PR220 - Reinforced Concrete Pile Cap/Footing	130	ft					130
PR234 - Reinforced Concrete Pier Cap	160	ft	128	32			0
PR313 - Fixed Bearing	22	each		22			0
515 - Steel Protective Coating	44	ft^2		44			0
PR800 - Erosion or Scour	226	ft	226				0
PR831 - Steel Beam End	28	each	22	6			0
PR852 - Pier Pedestal	22	each		22			0
12 - Reinforced Concrete Deck	15120	ft^2	6949	8099	72		0
510 - Wearing Surfaces	14040	ft^2	8465	5500	75		0
107 - Steel Open Girder/Beam	1802	ft	1802				0
515 - Steel Protective Coating	27787	ft^2	27787				0
330 - Metal Bridge Railing	318	ft	238	80			0
515 - Steel Protective Coating	711	ft^2	534	177			0
811 - Curb	424	ft	212	212			0
830 - Secondary Members	1	each	1				0
Span Number : 11							
PR205 - Reinforced Concrete Column	4	each	4				0
PR220 - Reinforced Concrete Pile Cap/Footing	130	ft					130
PR234 - Reinforced Concrete Pier Cap	128	ft	128				0
PR311 - Movable Bearing	17	each	17				0
515 - Steel Protective Coating	34	ft^2		34			0
PR800 - Erosion or Scour	216	ft	206	10			0
PR852 - Pier Pedestal	17	each	17				0
12 - Reinforced Concrete Deck	20736	ft^2	5016	15670	50		0
510 - Wearing Surfaces	19116	ft^2	11516	7500	100		0
107 - Steel Open Girder/Beam	2754	ft	2479	275			0
515 - Steel Protective Coating	42467	ft^2	38200	4267			0
330 - Metal Bridge Railing	486	ft	367	119			0

Element**	Total Quantity	Unit	CS-1	CS-2	CS-3	CS-4	CS-5
515 - Steel Protective Coating	1081	ft^2	811	270			0
811 - Curb	648	ft	324	324			0
830 - Secondary Members	1	each	1				0
Span Number : 12							
PR205 - Reinforced Concrete Column	4	each		4			0
PR220 - Reinforced Concrete Pile Cap/Footing	130	ft					130
PR234 - Reinforced Concrete Pier Cap	128	ft		82	46		0
PR305 - Assembly Joint without Seal	128	ft		118	10		0
PR311 - Movable Bearing	34	each		17	17		0
515 - Steel Protective Coating	68	ft^2			68		0
PR800 - Erosion or Scour	216	ft	201	15			0
PR831 - Steel Beam End	17	each		17			0
PR852 - Pier Pedestal	34	each		25	9		0
12 - Reinforced Concrete Deck	13568	ft^2	5113	8419	36		0
510 - Wearing Surfaces	12508	ft^2	6408	6000	100		0
107 - Steel Open Girder/Beam	1802	ft	1620	182			0
515 - Steel Protective Coating	27787	ft^2	22229	5558			0
330 - Metal Bridge Railing	318	ft	238	80			0
515 - Steel Protective Coating	711	ft^2	534	177			0
811 - Curb	424	ft	212	212			0
830 - Secondary Members	1	each		1			0
Span Number : 13							
PR205 - Reinforced Concrete Column	4	each	4				0
PR220 - Reinforced Concrete Pile Cap/Footing	130	ft					130
PR234 - Reinforced Concrete Pier Cap	128	ft	115	13			0
PR311 - Movable Bearing	17	each	17				0
515 - Steel Protective Coating	34	ft^2	34				0
PR800 - Erosion or Scour	216	ft	216				0
PR831 - Steel Beam End	17	each	12	5			0
PR852 - Pier Pedestal	17	each	17				0
12 - Reinforced Concrete Deck	11232	ft^2	4940	6260	32		0
510 - Wearing Surfaces	14042	ft^2	7682	6300	60		0
107 - Steel Open Girder/Beam	2023	ft	2018	5			0
515 - Steel Protective Coating	31195	ft^2	28075	3120			0
330 - Metal Bridge Railing	357	ft	268	89			0
515 - Steel Protective Coating	797	ft^2	598	199			0
811 - Curb	476	ft	238	238			0

Element**	Total Quantity	Unit	CS-1	CS-2	CS-3	CS-4	CS-5
830 - Secondary Members	1	each	1				0
Span Number : 14							
PR210 - Reinforced Concrete Pier Wall	72	ft	72				0
PR220 - Reinforced Concrete Pile Cap/Footing	130	ft					130
PR234 - Reinforced Concrete Pier Cap	128	ft	128				0
PR313 - Fixed Bearing	17	each	17				0
515 - Steel Protective Coating	34	ft^2	34				0
PR800 - Erosion or Scour	216	ft	216				0
PR852 - Pier Pedestal	17	each		17			0
12 - Reinforced Concrete Deck	20736	ft^2	5666	15024	46		0
510 - Wearing Surfaces	19116	ft^2	10716	8300	100		0
107 - Steel Open Girder/Beam	2754	ft	2479	275			0
515 - Steel Protective Coating	42467	ft^2	33549	8493	425		0
330 - Metal Bridge Railing	486	ft	364	122			0
515 - Steel Protective Coating	1081	ft^2	811	270			0
811 - Curb	648	ft	324	324			0
830 - Secondary Members	1	each	1				0
Span Number : 15							
EA215 - Reinforced Concrete Abutment	128	ft		125	3		0
EA220 - Reinforced Concrete Pile Cap/Footing	130	ft					130
EA311 - Movable Bearing	17	each		11	6		0
515 - Steel Protective Coating	34	ft^2		24		10	0
EA321 - Reinforced Concrete Approach Slab	7436	ft^2		7420	16		0
EA800 - Erosion or Scour	130	ft		130			0
EA850 - Backwall	128	ft		126	2		0
EA851 - Abutment Pedestal	17	each		17			0
EW220 - Reinforced Concrete Pile Cap/Footing	240	ft					240
EW800 - Erosion or Scour	240	ft		240			0
EW853 - Wingwall	240	ft		240			0
12 - Reinforced Concrete Deck	15360	ft^2	9586	5772	2		0
510 - Wearing Surfaces	14160	ft^2	8025	6060	75		0
107 - Steel Open Girder/Beam	2040	ft	1836	204			0
515 - Steel Protective Coating	31457	ft^2	25166	6291			0
330 - Metal Bridge Railing	360	ft	255	90	15		0
515 - Steel Protective Coating	804	ft^2	603	201			0
811 - Curb	480	ft	240	240			0
830 - Secondary Members	1	each	1				0

** Elements with a prefix designate the locations of BA-Begin Abutment, BW-Begin Wingwall, EA-End Abutment, EW-End Wingwall, CO-Culvert Outlet, and PR-Pier. No prefix generally indicates the element is part of the superstructure.

Inspection Notes

General Notes

1. The BIN plate is located on the Begin Abutment Stem under Girder G9 and is in OK condition. (Photo 1)
2. 100% Hands-on inspection was performed at all horizontal gusset plate welds connecting lateral bracing to girder bottom flanges in all spans. (Photos 2-3) Ref. Special Emphasis Sketches.
3. A minimum of 20% area of the underside of the overhangs were sounded and no loose concrete was found.
4. Brick veneer at all Abutment Wingwalls was inspected and no loose bricks were found.
5. There are no changes to the Access or Electrical Forms. Updated Debris Form is attached.
6. Vertical Clearance sketches are attached.
7. Joint Maintenance Report is attached.
8. Standard Photos have been updated where appropriate.
9. Two NSCO Reports were issued during this inspection. Previously issued NSCO report for debris at the top of cap beams is not a safety issued, therefore it was not re-issued.

Element Condition Notes

	TQ	CS-1	CS-2	CS-3	CS-4	CS-5
Span 1: 12 - Reinforced Concrete Deck	13440	5219	8027	194	0	0
Span 2: 12 - Reinforced Concrete Deck	19072	5862	13020	190	0	0
Span 4: 12 - Reinforced Concrete Deck	14336	4151	10153	32	0	0
Span 5: 12 - Reinforced Concrete Deck	20256	6480	13684	92	0	0
Span 6: 12 - Reinforced Concrete Deck	14102	4992	9070	40	0	0
Span 7: 12 - Reinforced Concrete Deck	14976	7405	7544	27	0	0
Span 8: 12 - Reinforced Concrete Deck	19230	5690	13510	30	0	0
Span 9: 12 - Reinforced Concrete Deck	16520	6365	10113	42	0	0
Span 10: 12 - Reinforced Concrete Deck	15120	6949	8099	72	0	0
Span 11: 12 - Reinforced Concrete Deck	20736	5016	15670	50	0	0
Span 12: 12 - Reinforced Concrete Deck	13568	5113	8419	36	0	0
Span 13: 12 - Reinforced Concrete Deck	11232	4940	6260	32	0	0
Span 14: 12 - Reinforced Concrete Deck	20736	5666	15024	46	0	0
Span 15: 12 - Reinforced Concrete Deck	15360	9586	5772	2	0	0

Common

Referenced Photo(s): 7, 8, 9, 10, 11, 12, 13, 14

Referenced Sketch(es): 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20

The (8" thick) reinforced concrete deck underside of exhibits the following defects:
- Spalls up to 3" deep with exposed epoxy painted or corroded rebar. (Photos 7-9,11,12, & 14)
- Transverse cracks up to 1/4" wide with/without efflorescence.(Photo 10 & 14)
- Fine mapcracking with/without efflorescence. (Photo 10,11, & 13)
- Areas of dampness on the underside of the deck due to seepage through the concrete deck. (Photo 10,11,13, & 14)

See attached Underside of Deck sketches for details and locations.

	TQ	CS-1	CS-2	CS-3	CS-4	CS-5
Span 1: 12 - Reinforced Concrete Deck-510 - Wearing Surfaces	12390	0	12290	100	0	0
Span 2: 12 - Reinforced Concrete Deck-510 - Wearing Surfaces	17582	7482	10000	100	0	0

Condition State 3 Note

Referenced Photo(s): 15

Referenced Sketch(es): None

The concrete wearing surface exhibits several shallow spalls up to 2 SF in the WB roadway. Additionally, there are scattered uneven asphalt patches throughout.

Span 1: BA215 - Reinforced Concrete Abutment

TQ	CS-1	CS-2	CS-3	CS-4	CS-5
128	50	75	3	0	0

Condition State 3 Note

Referenced Photo(s): 16

Referenced Sketch(es): None

Begin Abutment reinforced concrete stemwall adjacent to left wingwall exhibits spall up to 3' wide x full height x 2.5" deep with exposed and partially debonded corroded vertical rebar. In addition, there are scattered vertical cracks up 3/16" wide along the bottom of the wall.

Span 1: BA311 - Movable Bearing

TQ	CS-1	CS-2	CS-3	CS-4	CS-5
17	16	0	1	0	0

Condition State 3 Note

Referenced Photo(s): 17

Referenced Sketch(es): None

Girder G1 Bearing exhibits pack rust up to 1/2" between the rocker and masonry plate and minor pitting section loss.

Span 1: BA311 - Movable Bearing-515 - Steel Protective Coating

TQ	CS-1	CS-2	CS-3	CS-4	CS-5
34	32	0	0	2	0

Condition State 4 Note

Referenced Photo(s): 17

Referenced Sketch(es): None

At the Begin Abutment, the paint at the Girder G1 Bearing has failed allowing corrosion of the bearing steel.

Span 1: BA850 - Backwall

TQ	CS-1	CS-2	CS-3	CS-4	CS-5
128	0	126	2	0	0

Condition State 3 Note

Referenced Photo(s): 18

Referenced Sketch(es): None

The backwall exhibits a 2' (L) x up to 1" (W) diagonal crack at the top left corner of the backwall to the left of Girder G1. The area of backwall above the diagonal crack is hollow sounding but stable.

Span 1: PR852 - Pier Pedestal

TQ	CS-1	CS-2	CS-3	CS-4	CS-5
17	0	16	1	0	0

Condition State 3 Note

Referenced Photo(s): 19

Referenced Sketch(es): None

Pier 1, pedestal #10 at left face exhibits a spall up to 27" L x 16" H x 4" deep with exposed corroded and debonded horizontal rebar with cracks up to 1/4" (W). The bearing is not undermined.

	TQ	CS-1	CS-2	CS-3	CS-4	CS-5
Span 2: 330 - Metal Bridge Railing	447	317	112	18	0	0
Span 3: 330 - Metal Bridge Railing	315	222	79	14	0	0
Span 4: 330 - Metal Bridge Railing	336	240	84	12	0	0
Span 15: 330 - Metal Bridge Railing	360	255	90	15	0	0

Condition State 3 Note

Referenced Photo(s): 5, 6, 20

Referenced Sketch(es): None

The median railing at the following locations has been impacted which has bent or broken the posts:

-Span 2, E/B Median Railing: 10’ (L) segment of impacted railing with one bent post. (Typical Photo 5)
-Span 3, W/B Median Railing: 14’ (L) segment of impacted railing with one bent post. (Photo 5)
-Span 4, E/B Median Railing: 12’ (L) segment of impacted railing with one bent post with a crack at its base. (Photo 6)
-Span 15, E/B Median Railing: 15’ (L) segment of impacted railing with one bent post with a crack at its base. (Typical Photo 6)

A NSCO report has been issued for these conditions.

Additionally, in Span 2, one segment of lower rail at the right side railing is bent upward by 2". (Photo 20)

	TQ	CS-1	CS-2	CS-3	CS-4	CS-5
Span 3: 12 - Reinforced Concrete Deck	13440	5506	7887	47	0	0

Common

Referenced Photo(s): 21, 22, 23

Referenced Sketch(es): 8

The (8" thick) reinforced concrete deck underside of exhibits the following defects:
- Spalls up to 3" deep with exposed epoxy painted or corroded rebar. (Photos 22)
- Transverse cracks up to 1/4" wide with/without efflorescence. (Photo 23)
- Fine mapcracking with/without efflorescence. (Photo 23)
- Areas of dampness on the underside of the deck due to seepage through the concrete deck. (Photo 23)
- At the Pier 3 finger joint, the underside of the concrete deck adjacent to the joint in Bays 9 and 10 under the median at GCP E/B is spalled up to 8' (W) x 10.5" (H) x 6.5" (D). (Photo 21)

See attached Underside of Deck sketch for details and locations.

	TQ	CS-1	CS-2	CS-3	CS-4	CS-5
Span 3: 12 - Reinforced Concrete Deck-510 - Wearing Surfaces	12390	6240	6000	150	0	0

Condition State 3 Note

Referenced Photo(s): 24

Referenced Sketch(es): None

The concrete wearing surface exhibits two spalls (2 SF & 5 SF) up to 2" (D) with exposed deck reinforcement in the WB center lane. Additionally, there are scattered uneven asphalt patches throughout.

	TQ	CS-1	CS-2	CS-3	CS-4	CS-5
Span 3: PR234 - Reinforced Concrete Pier Cap	128	0	77	51	0	0

Condition State 3 Note

Referenced Photo(s): 25

Referenced Sketch(es): None

The underside of the left Pier Cap exhibits a 3' W x 4' L x up to 2" D spall with exposed corroded rebar. The begin face of the Pier Cap under Bay 6 exhibits a 2 SF x up to 2" D spall with exposed corroded rebar. Additionally, the Pier Cap exhibits scattered cracking up to 1/8" (W) throughout the begin and end faces.

	TQ	CS-1	CS-2	CS-3	CS-4	CS-5
Span 3: PR305 - Assembly Joint without Seal	128	0	120	8	0	0

Condition State 3 Note

Referenced Photo(s): 26

Referenced Sketch(es): None

The finger joint is filled with dirt and debris which inhibits proper functioning of the joint. There is evidence of water leakage on the Pier Cap below.

	TQ	CS-1	CS-2	CS-3	CS-4	CS-5
Span 3: PR852 - Pier Pedestal	35	0	31	4	0	0

Condition State 3 Note

Referenced Photo(s): 19, 27

Referenced Sketch(es): None

Pier 3, following reinforced concrete pedestals are spalled with/without exposed corroded rebars as follows:
- Pedestal #5, Span 3 side; 4.7 SF (Full Face) x 2 ½" spall at end face. (Typical Photo 19)
- Pedestal #6, Span 3 side; 1 SF x 1 ½" deep at begin face. Full width x 6" high x 1"deep at end face. (Typical Photo 19)
- Pedestal #6, Span 4 side; Full length horizontal crack (up to 3/16") w/hollow sound at end face. (Typical Photo 19)

Bearings are not undermined and the cores of the spalled concrete are solid.

Previously noted spall at Pedestal #15 has been repaired. (Photo 27) Ref. Improvements Observed.

	TQ	CS-1	CS-2	CS-3	CS-4	CS-5
Span 4: 12 - Reinforced Concrete Deck-510 - Wearing Surfaces	13216	6900	6216	100	0	0
Span 5: 12 - Reinforced Concrete Deck-510 - Wearing Surfaces	18644	0	18569	75	0	0
Span 6: 12 - Reinforced Concrete Deck-510 - Wearing Surfaces	12980	7000	5980	0	0	0
Span 8: 12 - Reinforced Concrete Deck-510 - Wearing Surfaces	17700	9650	8000	50	0	0
Span 9: 12 - Reinforced Concrete Deck-510 - Wearing Surfaces	15340	8765	6500	75	0	0
Span 10: 12 - Reinforced Concrete Deck-510 - Wearing Surfaces	14040	8465	5500	75	0	0
Span 11: 12 - Reinforced Concrete Deck-510 - Wearing Surfaces	19116	11516	7500	100	0	0
Span 13: 12 - Reinforced Concrete Deck-510 - Wearing Surfaces	14042	7682	6300	60	0	0
Span 15: 12 - Reinforced Concrete Deck-510 - Wearing Surfaces	14160	8025	6060	75	0	0

Condition State 3 Note

Referenced Photo(s): 28, 29

Referenced Sketch(es): None

There are scattered uneven asphalt patches throughout the EB & WB roadways.

	TQ	CS-1	CS-2	CS-3	CS-4	CS-5
Span 4: PR234 - Reinforced Concrete Pier Cap	128	0	123	5	0	0

Condition State 3 Note

Referenced Photo(s): 30

Referenced Sketch(es): None

The Pier Cap exhibits a spall with exposed and rusted rebar at the end and bottom faces. At the left Pier Cap on the end face under Bay 6 there is a 2 SF x up to 2" (D) spall with exposed rebar.

	TQ	CS-1	CS-2	CS-3	CS-4	CS-5
Span 6: PR234 - Reinforced Concrete Pier Cap	128	101	20	7	0	0

Condition State 3 Note

Referenced Photo(s): 31, 32, 33

Referenced Sketch(es): None

Pier Cap at begin face exhibits the following defects:
- Under Bay 1: Spall 4 SF x up to 2.5" Deep with exposed corroded rebar.
- Under Bay 15: Scattered horizontal cracks up to 1/8" (W) with rust bleed. (Photo 33)

Pier Cap at the end face exhibits the following defects:
- Under Bays 17-18: two spalls totaling 5' in length x Full Height x up to 2" deep spall with exposed rebar and a 2 SF x up to 2" (D) spall on the underside. (Photo 32)
- Under Bay 12: 2 SF x up to 3" (D) spall with exposed rebar. (Photo 31)
- Under Bay 14: 2 SF x up to 1 1/2" (D) spall with exposed rebar.

	TQ	CS-1	CS-2	CS-3	CS-4	CS-5
Span 6: PR311 - Movable Bearing-515 - Steel Protective Coating	74	0	0	74	0	0
Span 9: PR311 - Movable Bearing-515 - Steel Protective Coating	82	0	20	62	0	0
Span 12: PR311 - Movable Bearing-515 - Steel Protective Coating	68	0	0	68	0	0

Condition State 3 Note

Referenced Photo(s): 38

Referenced Sketch(es): None

All rocker bearings at Piers 6, 9, and 12 exhibit paint that is becoming ineffective especially at the rocker and at the masonry plates.

	TQ	CS-1	CS-2	CS-3	CS-4	CS-5
Span 6: PR311 - Movable Bearing	37	0	30	7	0	0

Common

Referenced Photo(s): 34, 35, 36, 37

Referenced Sketch(es): 21

Span 6 side rocker bearings exhibt the following at an ambient temparature of 43 degrees F:
- Bearings #1-13 & 18, varying from upright to tilting in expansion mode up to 1 degree. [CS-2]
- Bearing #14 expanded by 6 degrees. (Photo 36) [CS-3]
- Bearing #15-16 expanded by 4 degrees. (Photo 37) [CS-3]
- Bearing #17 expanded by 2.5 degrees [CS-3]

[Ref. High Rocker Bearing Table]

Span 7 side rocker bearings exhibit the following at an ambient temperature of 43 degrees:
- Vary from upright position to tilting in expansion mode up to 1.5 degrees, worst at bearings 9-11. [CS-2]
- Bearings # 5, 6 and 7 have exposed pintles with up to 1/2" space partially between the rocker and the masonry plate. (Photo 35) [CS-3]
- All bearings have up to ½" pack rust between the curved rocker and the masonry plate. (Photo 34) [CS-2]

	TQ	CS-1	CS-2	CS-3	CS-4	CS-5
Span 6: PR852 - Pier Pedestal	37	0	33	4	0	0

Condition State 3 Note

Referenced Photo(s): 39, 40

Referenced Sketch(es): None

At the Span 6 side, Pedestals at Bearings 15, 17, & 19 exhibit cracks up to 1/8" (W) at the right faces (Photo 40). Additionally at the Span 6 side, the end face of Pedestal at Bearing G1 exhibits a 2 SF x up to 1" (D) with exposed corroded rebar (Photo 39). Bearings are not undermined and the cores of the spalled concrete are solid.

	TQ	CS-1	CS-2	CS-3	CS-4	CS-5
Span 7: 12 - Reinforced Concrete Deck-510 - Wearing Surfaces	13806	7440	6306	60	0	0

Condition State 3 Note

Referenced Photo(s): 41

Referenced Sketch(es): None

The concrete wearing surface exhibits a 1 SF x up to 2" (D) spall with water ponding in the WB center lane. Additionally, there are scattered uneven asphalt patches throughout.

	TQ	CS-1	CS-2	CS-3	CS-4	CS-5
Span 8: PR234 - Reinforced Concrete Pier Cap	128	126	0	2	0	0

Condition State 3 Note

Referenced Photo(s): 42

Referenced Sketch(es): None

Below Girder G12, the Pier Cap exhibits a 4 SF x up to 1 1/2" (D) spall with exposed rebar and the right face. Additionally, on the underside of the Pier Cap under Girder G12 there is a 1 SF x up to 1" (D) spall with exposed rebar.

	TQ	CS-1	CS-2	CS-3	CS-4	CS-5
Span 9: PR234 - Reinforced Concrete Pier Cap	128	0	98	30	0	0

Condition State 3 Note

Referenced Photo(s): 43, 44

Referenced Sketch(es): None

The begin face of the Pier Cap under Bays 9-10 exhibits vertical and horizontal scattered cracking up to 1/8" (W) with efflorescence and rust staining. (Photo 43)

The end face of the Pier Cap under Bays 6-7 exhibits scattered spalling up to 1 1/2" (D). Additionally under Girder G11, there is a 6' (L) x 3' (H) x up to 3" (D) spall with exposed corroded main reinforcement. (Photo 44)

Span 9: PR311 - Movable Bearing

TQ	CS-1	CS-2	CS-3	CS-4	CS-5
41	0	40	1	0	0

Common

Referenced Photo(s): 38

Referenced Sketch(es): None

At the Span 10 side, Girder G14 bearing is expaned by 4 degrees at an ambient temperature of 65 degrees F. (CS-3) All other bearings are upright or slightly expanded with minor pack rust build-up below the rockers.(CS-2)

Span 9: 330 - Metal Bridge Railing

TQ	CS-1	CS-2	CS-3	CS-4	CS-5
354	257	89	8	0	0

Condition State 3 Note

Referenced Photo(s): 20

Referenced Sketch(es): None

In Span 9 over Pier 9, one segment of lower rail at the right side railing is bent upward by 2".

Span 9: PR852 - Pier Pedestal

TQ	CS-1	CS-2	CS-3	CS-4	CS-5
41	0	36	5	0	0

Condition State 3 Note

Referenced Photo(s): 45, 46

Referenced Sketch(es): None

Pier 9, has 19 pedestals at span 9 side and 22 pedestals at span 10 side.
- Pedestal #14 at Span 9 side and #18 at Span 10 side is spalled at left face up to 27" (W) x 13" (H) x up to 2.5" (D) and 24" (W) x 13" (H) x up to 2" (D), respectively, with exposed corroded rebar.
- Pedestal #21 at the Span 10 side has a 1 (W)' x Full Height x up to 2.5" (D) spall with exposed rebars at the right face and horizontal cracks up to 1/8" (W) (Photo 45).
- Pedestal #19 on the Span 9 side and #21 at the Span 10 side exhibit vertical and horizontal cracks up to 1/8" (W) on the right face of Pier 9. (Photo 46)

Bearings are not undermined and the cores of the spalled concrete are solid.

Span 11: PR800 - Erosion or Scour

TQ	CS-1	CS-2	CS-3	CS-4	CS-5
216	206	10	0	0	0

Condition State 2 Note

Referenced Photo(s): 47

Referenced Sketch(es): None

Between Columns C3 and C4, there is a 10' wide area of eroded soil up to 1' deep. The columns and footings are not affected.

Span 12: 12 - Reinforced Concrete Deck-510 - Wearing Surfaces

TQ	CS-1	CS-2	CS-3	CS-4	CS-5
12508	6408	6000	100	0	0

Condition State 3 Note

Referenced Photo(s): 41

Referenced Sketch(es): None

The concrete wearing surface exhibits a 3 SF x up to 2" (D) spall with water ponding in the EB center lane. Additionally, there are scattered uneven asphalt patches throughout.

Span 12: PR234 - Reinforced Concrete Pier Cap

TQ	CS-1	CS-2	CS-3	CS-4	CS-5
128	0	82	46	0	0

Condition State 3 Note

Referenced Photo(s): 48

Referenced Sketch(es): None

At the left Pier Cap between Columns C1 and C2, there is mapcracking on all faces up to 1/8" (W) with efflorescence on the underside of the Pier Cap. Additionally, At the right Pier Cap between Columns C3 and C4, there are 10' (L) x up to 1/4" (W) horizontal cracks with rust bleed at the bottom of the begin and end faces.

Span 12: PR305 - Assembly Joint without Seal

TQ	CS-1	CS-2	CS-3	CS-4	CS-5
128	0	118	10	0	0

Condition State 3 Note

Referenced Photo(s): 49

Referenced Sketch(es): None

The 10' section of the Finger Joint near the median at the EB roadway is filled with dirt and debris. Below deck, there is active water leakage in bays 5 & 10.

Span 12: PR311 - Movable Bearing

TQ	CS-1	CS-2	CS-3	CS-4	CS-5
34	0	17	17	0	0

Condition State 3 Note

Referenced Photo(s): 34

Referenced Sketch(es): None

Pier 12, end rocker bearings at (Span 13 side) exhibit the following:
- Upright to tilt with an expansion mode with an angle varies from (0 to 4) in an ambient temperature of 65 degrees Fahrenheit.
- All bearings have up to ¼" pack rust between the curved rocker and the masonry plate.

Span 12: PR852 - Pier Pedestal

TQ	CS-1	CS-2	CS-3	CS-4	CS-5
34	0	25	9	0	0

Condition State 3 Note

Referenced Photo(s): 50, 51

Referenced Sketch(es): None

Pier 12 pedestals exhibit the following defects:
- Span 12 side Pedestal #2 has cracks up to 1/8" (W) at the left and end faces.
- Span 12 side Pedestal #3 has a 1 SF x up to 1 1/2" (D) spall with exposed rebar at the end face.
- Spans 12-13 Pedestal #4 exhibit horizontal cracks up to 1/8" (W) at the right face. (Photo 50)
- Span 12 side Pedestal #8 has a 1 SF x up to 1 1/2" (D) spall with exposed rebar at the begin face. (Photo 51)
- Span 13 side Pedestal #2 has cracks up to 1/8" (W) on the left face.
- Span 13 side Pedestal #10-12 have cracks up to 1/8" (W) on the end face.

Bearings are not undermined and the cores of the spalled concrete are solid.

Span 14: 12 - Reinforced Concrete Deck-510 - Wearing Surfaces

TQ	CS-1	CS-2	CS-3	CS-4	CS-5
19116	10716	8300	100	0	0

Condition State 3 Note

Referenced Photo(s): 41

Referenced Sketch(es): None

The concrete wearing surface exhibits a 2 SF x up to 2" (D) spall with water ponding in the EB center lane. Additionally, there are scattered uneven asphalt patches throughout.

Span 14: 107 - Steel Open Girder/Beam-515 - Steel Protective Coating

TQ	CS-1	CS-2	CS-3	CS-4	CS-5
42467	33549	8493	425	0	0

Condition State 3 Note

Referenced Photo(s): 52

Referenced Sketch(es): None

Near midspan, there is a localized area of cracked and peeling paint on Girders G7 & G8.

Span 15: EA215 - Reinforced Concrete Abutment

TQ	CS-1	CS-2	CS-3	CS-4	CS-5
128	0	125	3	0	0

Condition State 3 Note

Referenced Photo(s): 53

Referenced Sketch(es): None

At the left corner of the end abutment, there are two spalls (1 SF & 2 SF) x up to 1 1/2" (D) with exposed rebar.

Span 15: EA311 - Movable Bearing

TQ	CS-1	CS-2	CS-3	CS-4	CS-5
17	0	11	6	0	0

Condition State 3 Note

Referenced Photo(s): 55

Referenced Sketch(es): None

The paint at the masonry plate and the rocker, for the bearings of Girders G1, G10-12 & G17, has failed leading to moderate corrosion with minor section loss. Additionally, the bearing for Girder G1 exhibits up to 1/2" pack rust between the rocker and masonry plate.
Also all bearings are in slight contraction position at 52 Degrees F.

Span 15: EA311 - Movable Bearing-515 - Steel Protective Coating

TQ	CS-1	CS-2	CS-3	CS-4	CS-5
34	0	24	0	10	0

Condition State 4 Note

Referenced Photo(s): 55

Referenced Sketch(es): None

The paint at the masonry paint and the rocker of the bearing for Girders G1, G10-12 & G17,has failed leading to moderate corrosion with minor section loss.

Span 15: EA321 - Reinforced Concrete Approach Slab

TQ	CS-1	CS-2	CS-3	CS-4	CS-5
7436	0	7420	16	0	0

Condition State 3 Note

Referenced Photo(s): 54

Referenced Sketch(es): None

The end abutment joint is behind the front face of the backwall, therefore it is not rated as a joint. The following joint defect is rated with the end approach slab:
Approximately 12' of the joint filler material in the EB roadway and 4' in the WB roadway is deteriorated and not fully bonded. The majority of the joint is filled with debris at the EB roadway.

Span 15: 811 - Curb

TQ	CS-1	CS-2	CS-3	CS-4	CS-5
480	240	240	0	0	0

Condition State 2 Note

Referenced Photo(s): 56

Referenced Sketch(es): None

There is a gap between the wearing surface and the left curb which is causing water to flow down the the left corner of the abutment and causing corrosion to several items.

Span 15: EA850 - Backwall

TQ	CS-1	CS-2	CS-3	CS-4	CS-5
128	0	126	2	0	0

Condition State 3 Note

Referenced Photo(s): 57

Referenced Sketch(es): None

The backwall exhibits a 2 SF x up to 3" (D) spall at the top left corner near Girder G1.

Non-Structural Condition Observations

Category: DRAINAGE - Scupper issues (clogged, ponding, etc.) Quantity: 3 Unit: ea Referenced Element(s): NONE Referenced Photo(s): 4 Referenced Sketch(es): NONE
In the Eastbound left lane at the following locations, the catch basins are 100% clogged with dirt and debris: -Span 5 near Pier 5 (Photo 1). -Span 9 near Pier 9 (Typical Photo 1). -Span 10 near Pier 10 (Typical Photo 1). There was a previously issued NSCO for a similar condition in Span 13, which has been cleared. The locations listed above are new.
Category: OTHER -Railings Quantity: 51 Unit: sqft Referenced Element(s): NONE Referenced Photo(s): 5,6 Referenced Sketch(es): NONE
The median railing at the following locations has been impacted which has bent or broken the posts: -Span 2, E/B Median Railing: 10’ (L) segment of impacted railing with one bent post. (Typical Photo 2) -Span 3, W/B Median Railing: 14’ (L) segment of impacted railing with one bent post. (Photo 2) -Span 4, E/B Median Railing: 12’ (L) segment of impacted railing with one bent post with a crack at its base. (Photo 3) -Span 15, E/B Median Railing: 15’ (L) segment of impacted railing with one bent post with a crack at its base. (Typical Photo 3) This is a new NSCO.

Inspection Photographs

	Photo Number: **1** Photo Filename: **20_SW_5586.JPG**
Attachment Description: Location: Begin Abutment under Girder G9; Looking Back. BIN Plate in OK condition. Ref. General Notes.	

	Photo Number: **2** Photo Filename: **20_SW_6110.JPG**
Attachment Description: Location: Span 9, Girder G7 at Diaph. D4; Looking Back. Bottom flange weld. Ref. Special Emphasis.	

Photo Number: **3** Photo Filename: **20_SW_6111.JPG**

Attachment Description:
Location: Span 9, Girder G4 at Diaph. D5; Looking Back. Bottom flange weld. Ref. Special Emphasis.

Photo Number: **4** Photo Filename: **20_SW_6075.JPG**

Attachment Description:
Location: Span 5, E/B Left Lane; Looking Back. Clogged catch basin. Ref. NSCO.

Attachment Description: Location: Span 3, W/B Median Railing; Looking Left. Impacted railing with bent post. (Typical) Ref. NSCO.	Photo Number: **5** Photo Filename: **20_SW_6067.JPG** 

Attachment Description: Location: Span 4, E/B Median Railing; Looking Back and Left. Impacted railing with bent/cracked post. (Typical) Ref. NSCO.	Photo Number: **6** Photo Filename: **20_SW_6072.JPG** 

Photo Number: **7** Photo Filename: **20_SW_5589.JPG**

Attachment Description:
Location: Span 1, Bay 13-14 at Diaph. D3; Looking Up and Back. Spalls with exposed rebar and efflorescence.

Photo Number: **8** Photo Filename: **20_SW_5596.JPG**

Attachment Description:
Location: Span 2, Bays 11-12 at Diaph. D5; Looking Up and Ahead. Spalls with exposed rebar and efflorescence.

	Photo Number: **9** Photo Filename: **20_SW_5616.JPG**
Attachment Description: Location: Spans 6-7 Left Overhang at Pier 6; Looking Up and Back. Spalls with exposed rebar and efflorescence.	

	Photo Number: **10** Photo Filename: **20_SW_6106.JPG**
Attachment Description: Location: Span 5, Bays 12-13 at Diaph. D3-5; Looking Up and Ahead. Dampness, fine mapcracking with/without efflorescence.	

Photo Number: **11** Photo Filename: **20_SW_6103.JPG**

Attachment Description:
Location: Span 5, Bays 15-17 at Diaph. D5-6; Looking Up and Back. Spalls with exposed rebar, dampness, and mapcracking.

Photo Number: **12** Photo Filename: **20_SW_6102.JPG**

Attachment Description:
Location: Spans 6-7 Right Overhang at Pier 6; Looking Up and Left. Spalls with exposed rebar and efflorescence.

Attachment Description: Location: Span 11, Bays 10-14; Looking Up and Ahead. Dampness, fine mapcracking with/without efflorescence.	Photo Number: **13** Photo Filename: **20_SW_5680.JPG** 

Attachment Description: Location: Span 13, Bays 15-17 at Diaph. D3-4; Looking Up and Ahead. Dampness and spalls with exposed rebar and efflorescence.	Photo Number: **14** Photo Filename: **20_SW_5880.JPG** 

Photo Number: **15** Photo Filename: **20_SW_6060.JPG**

Attachment Description:
Location: Spans 1-2, W/B Wearing Surface; Looking Ahead and Left. Shallow spalls and uneven asphalt patches.

Photo Number: **16** Photo Filename: **20_SW_5580.JPG**

Attachment Description:
Location: Begin Abutment, Left Side; Looking Back and Right. Spall with exposed debonded rebar.

	Photo Number: **17** Photo Filename: **20_SW_5581.JPG**
Attachment Description: Location: Begin Abutment, Girder G1 Bearing; Looking Back. Pack rust, paint failure, and surface corrosion on the bearing plates.	

	Photo Number: **18** Photo Filename: **20_SW_5582.JPG**
Attachment Description: Location: Begin Abutment, Backwall, Left Side; Looking Back. Diagonal crack at top of backwall.	

Attachment Description: Location: Pier 1, Pedestal #10; Looking Ahead and Right. Spall with exposed rebar and cracks. (Typical)	Photo Number: **19** Photo Filename: **20_SW_5592.JPG** 

Attachment Description: Location: Span 2, Right Metal Railing; Looking Right. Bent lower rail. (Typical)	Photo Number: **20** Photo Filename: **20_SW_6062.JPG** 

Attachment Description: Location: Span 3, Bays 9-10 at Pier 3 Joint; Looking Right. Spalled underside of deck at joint.	Photo Number: **21** Photo Filename: **20_SW_5601.JPG** 

Attachment Description: Location: Span 3, Bay 9; Looking Back. Spalls with exposed concrete.	Photo Number: **22** Photo Filename: **20_SW_5606.JPG** 

Photo Number: **23** Photo Filename: **20_SW_5610.JPG**

Attachment Description:
Location: Span 3, Bays 12-14 at Diaph. D2-3; Looking Up and Back. Dampness, mapcracking, and spalls with efflorescence.

Photo Number: **24** Photo Filename: **20_SW_6065.JPG**

Attachment Description:
Location: Span 3, W/B Wearing Surface; Looking Left. Spalls and uneven asphalt patches.

	Photo Number: **25** Photo Filename: **20_SW_5649.JPG**
Attachment Description: Location: Pier 3, Pier Cap, Underside under Bay 3; Looking Up and Ahead. Spall with exposed rebar.	

	Photo Number: **26** Photo Filename: **20_SW_6069.JPG**
Attachment Description: Location: Pier 3, W/B Joint; Looking Left. Joint filled with dirt and debris.	

	Photo Number: **27** Photo Filename: **20_SW_5609.JPG**
Attachment Description: Location: Pier 3, Pedestal #15, end face; Looking Back. Repaired pedestal spall. Ref. Improvements Observed.	

	Photo Number: **28** Photo Filename: **20_SW_6074.JPG**
Attachment Description: Location: Span 5, W/B Wearing Surface; Looking Left. Potholes and uneven asphalt patches.	

Attachment Description: Location: Span 11, E/B Wearing Surface; Looking Ahead and Right. Potholes and uneven asphalt patches.	Photo Number: **29** Photo Filename: **20_SW_6083.JPG** 

Attachment Description: Location: Pier 4, Pier Cap, End Face under Bay 6; Looking Back and Left. Spall with exposed rebar.	Photo Number: **30** Photo Filename: **20_SW_5611.JPG** 

	Photo Number: **31** Photo Filename: **20_SW_5624.JPG**
Attachment Description: Location: Pier 6, Pier Cap, End Face under Bay 12; Looking Back. Spall with exposed rebar.	

	Photo Number: **32** Photo Filename: **20_SW_5634.JPG**
Attachment Description: Location: Pier 6, Pier Cap, End face under Bays 17-18; Looking Back. Spalls with exposed rebar.	

Attachment Description: Location: Pier 6, Begin Face under Bay 15; Looking Ahead and Left. Horizontal cracks with rust bleed.	Photo Number: **33** Photo Filename: **20_SW_5643.JPG** 

Attachment Description: Location: Pier 6, Bearing G2, Span 7 side; Looking Back. Pack rust between rocker and masonry plate and deteriorated paint. (Typical)	Photo Number: **34** Photo Filename: **20_SW_5614.JPG** 

Photo Number: **35** Photo Filename: **20_SW_5621.JPG**

Attachment Description:
Location: Pier 6, Bearing G5, Span 7 side; Looking Back and Right. Pack rust with exposed pintels.

Photo Number: **36** Photo Filename: **20_SW_5637.JPG**

Attachment Description:
Location: Pier 6, Bearing G14, Span 6 side; Looking Left. Bearing over-expanded.

Photo Number: **37** Photo Filename: **20_SW_5638.JPG**

Attachment Description:
Location: Pier 6, Bearing G15, Span 6 side; Looking Right. Bearing over-expanded.

Photo Number: **38** Photo Filename: **20_SW_6122.JPG**

Attachment Description:
Location: Pier 9, Bearing G14, Span 10 side; Looking Left. Bearing over-expanded.

Photo Number: **39** Photo Filename: **20_SW_5617.JPG**

Attachment Description:
Location: Pier 6, Pedestal #1, Span 6 side; Looking Back and Right. Spall with exposed rebar.

Photo Number: **40** Photo Filename: **20_SW_5641.JPG**

Attachment Description:
Location: Pier 6, Pedestal #15 (both spans); Looking Ahead and Left. Cracks at right face between Girder G15 pedestals.

Photo Number: **41** Photo Filename: **20_SW_6078.JPG**

Attachment Description:
Location: Span 7, W/B Wearing Surface; Looking Left. Potholes with water ponding and uneven asphalt patches. (Typical)

Photo Number: **42** Photo Filename: **20_SW_6127.JPG**

Attachment Description:
Location: Pier 8, Pier Cap, Underside Girder G12; Looking Ahead and Right. Spalls with exposed rebar.

Photo Number: **43** Photo Filename: **20_SW_6113.JPG**

Attachment Description:
Location: Pier 9, Pier Cap, Begin Face under Bays 9-10; Looking Ahead. Scattered cracks.

Photo Number: **44** Photo Filename: **20_SW_6128.JPG**

Attachment Description:
Location: Pier 9, Pier Cap, End Face under Girder G11; Looking Back. Spall with exposed main reinforcement.

Photo Number: **45** Photo Filename: **20_SW_6116.JPG**

Attachment Description:
Location: Pier 9, Pedestal #21, Span 10 side; Looking Back and Left. Spall and cracking.

Photo Number: **46** Photo Filename: **20_SW_6117.JPG**

Attachment Description:
Location: Pier 9, Right Face Pedestals; Looking Left. Scattered pedestal cracks.

Attachment Description: Location: Pier 11 between Columns C3-C4; Looking Ahead. Erosion between columns.	Photo Number: **47** Photo Filename: **20_SW_5683.JPG** 

Attachment Description: Location: Pier 12, Right Pier Cap between C3 and C4, Underside; Looking Back and Left. Horizontal cracks with rust bleed.	Photo Number: **48** Photo Filename: **20_SW_5878.JPG** 

Photo Number: **49** Photo Filename: **20_SW_6088.JPG**

Attachment Description:
Location: Pier 12, E/B Joint near median; Looking Right. Joint filled with dirt and debris.

Photo Number: **50** Photo Filename: **20_SW_6131.JPG**

Attachment Description:
Location: Pier 12, Pedestal #4, Right Face; Looking Back and Left. Horizontal cracks.

Photo Number: **51** Photo Filename: **20_SW_6135.JPG**

Attachment Description:
Location: Pier 12, Pedestal #8, Span 12 side; Looking Ahead. Spall with exposed rebar.

Photo Number: **52** Photo Filename: **20_SW_5863.JPG**

Attachment Description:
Location: Span 14, Girder G7 & G8 near midspan; Looking Left. Area of cracked and peeling paint.

Attachment Description: Location: End Abutment, Left Side; Looking Ahead. Spall with exposed rebar.	Photo Number: **53** Photo Filename: **20_SW_5858.JPG** 

Attachment Description: Location: End Abutment Joint, E/B; Looking Right. Joint seal is deteriorated and debonded.	Photo Number: **54** Photo Filename: **20_SW_6097.JPG** 

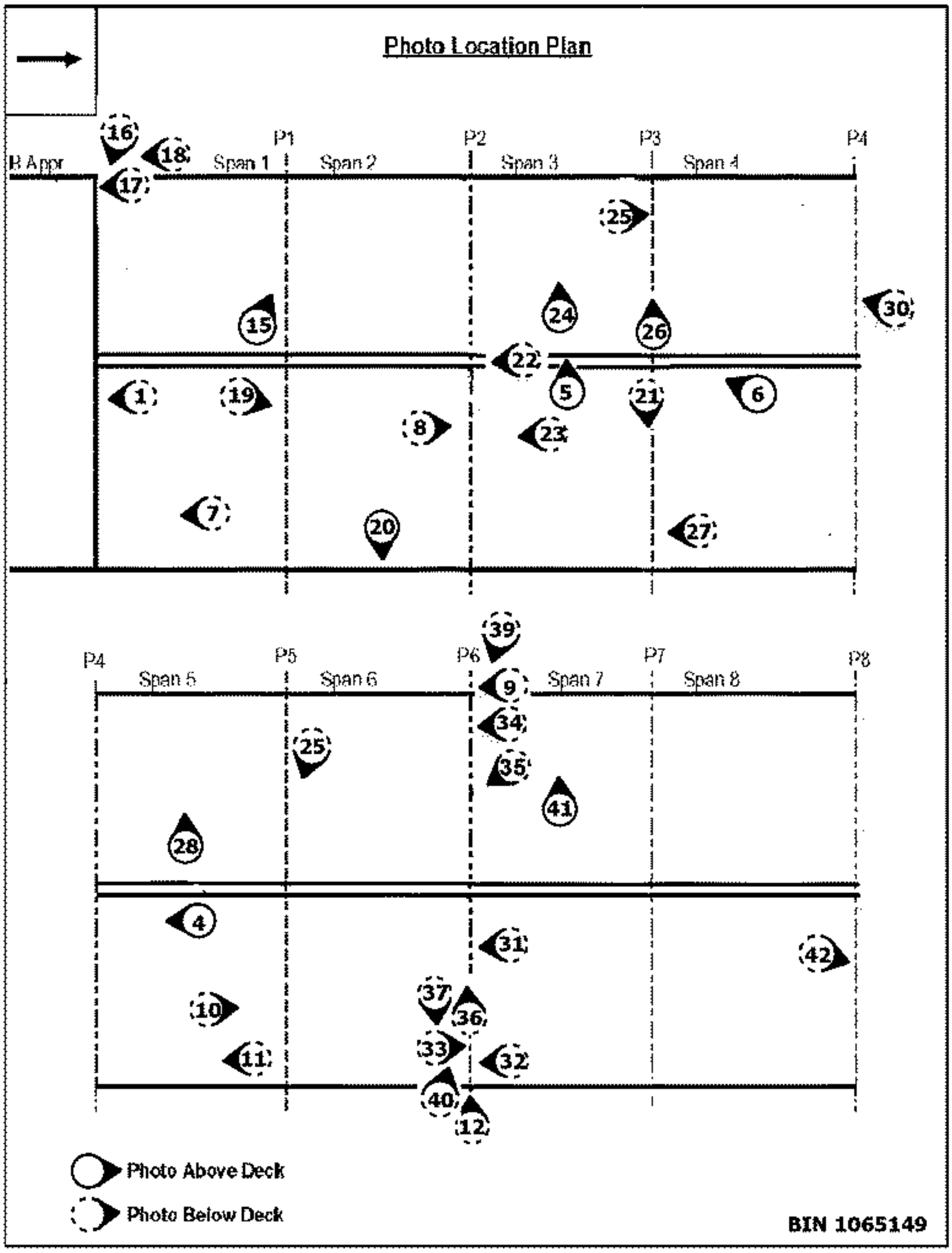
Attachment Description: Location: End Abutment, Bearing G17; Looking Ahead. Pack rust between rocker and masonry plate and deteriorated paint with surface corrosion.	Photo Number: **55** Photo Filename: **20_SW_5854.JPG** 

Attachment Description: Location: Span 15, Left Curb at End Abutment; Looking Down and Left. Gap between curb and concrete deck.	Photo Number: **56** Photo Filename: **20_SW_6138.JPG** 

	Photo Number: **57** Photo Filename: **20_SW_5859.JPG**
Attachment Description: Location: End Abutment Backwall, Left Side; Looking Ahead. Spall with exposed rebar.	

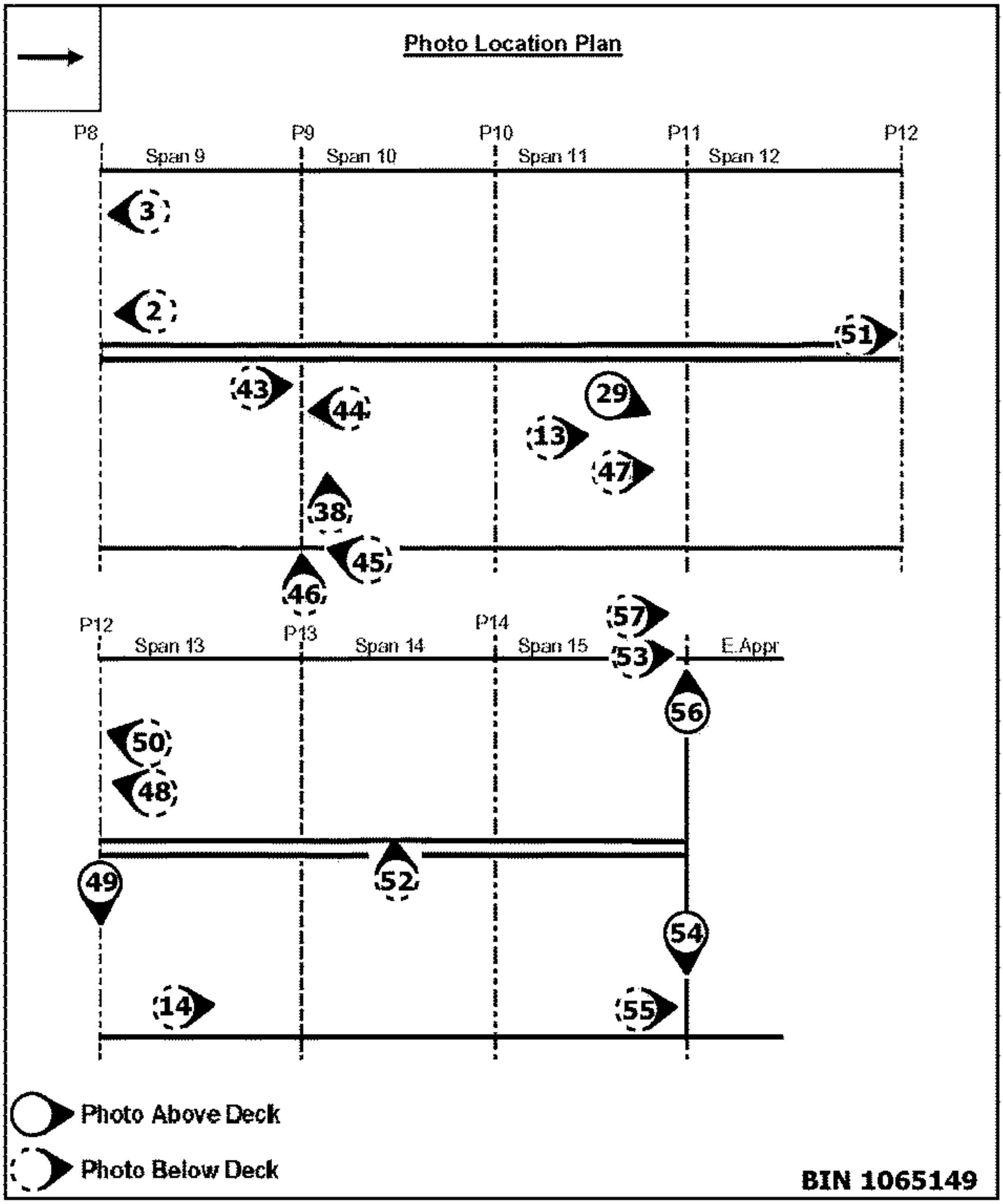
Inspection Sketches

Sketch Number: **1** Sketch Filename: **20_PhotoLocation1.jpg**



Sketch Description: Photo Location Plan (1 of 2)

Sketch Number: **2** Sketch Filename: **20_PhotoLocation2.jpg**



Sketch Description: Photo Location Plan (2 of 2)

Sketch Number: **3** Sketch Filename: **Special Emphasis Sketch 1_3.jpg**

SPECIAL EMPHASIS

LOCATION OF CRITICAL WELD DETAILS

NORTH

ALL DIAPHRAGM CONNECTIONS, BOTH INTERIOR AND EXTERIOR, ARE CRITICAL DETAILS. THERE IS A GUSSET PLATE WELDED TO THE LOWER FLANGE OF GIRDER WITH A LONGITUDINAL WELD GREATER THAN 4". THIS IS A CATEGORY E' DETAIL.

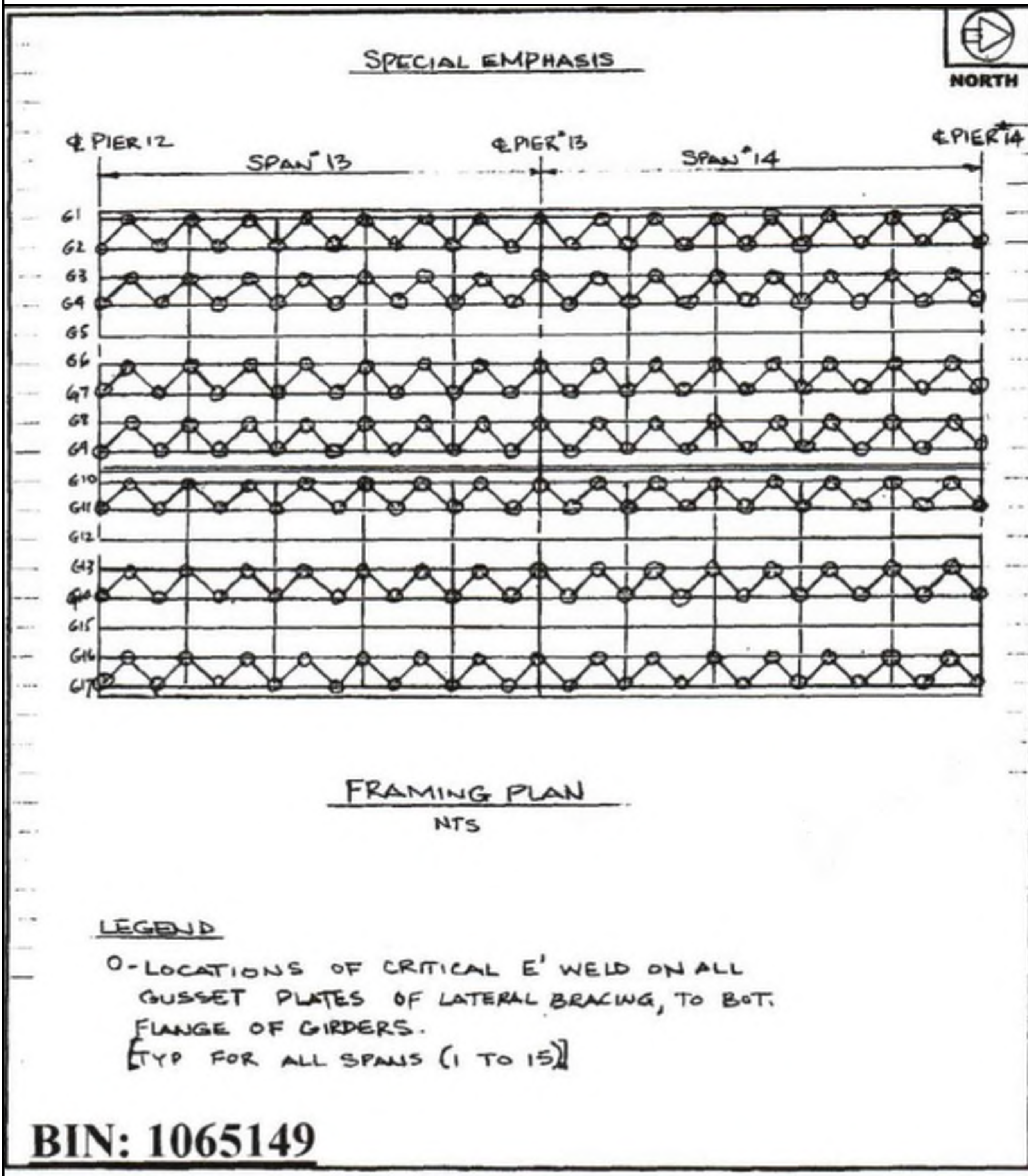
SEE DRAWING G-25, SHEET 203 CONTRACT GCP 70-1

SEE ATTACHED SKETCHES, SHEETS 4 and 5

BIN: 1065149

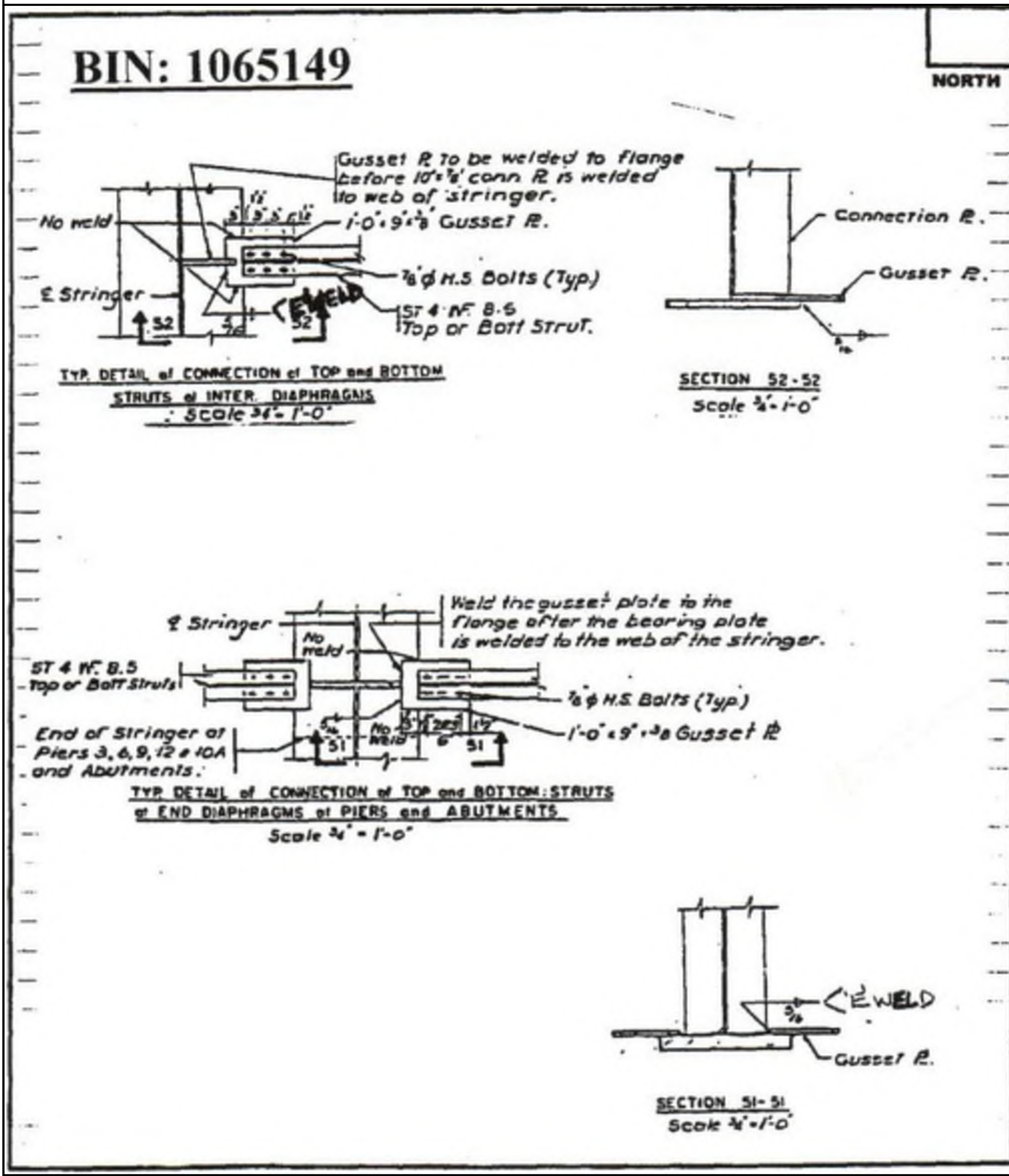
Sketch Description: Special Emphasis Sketch (1 of 3)

Sketch Number: **4**	Sketch Filename: **Special Emphasis Sketch 2_3.jpg**



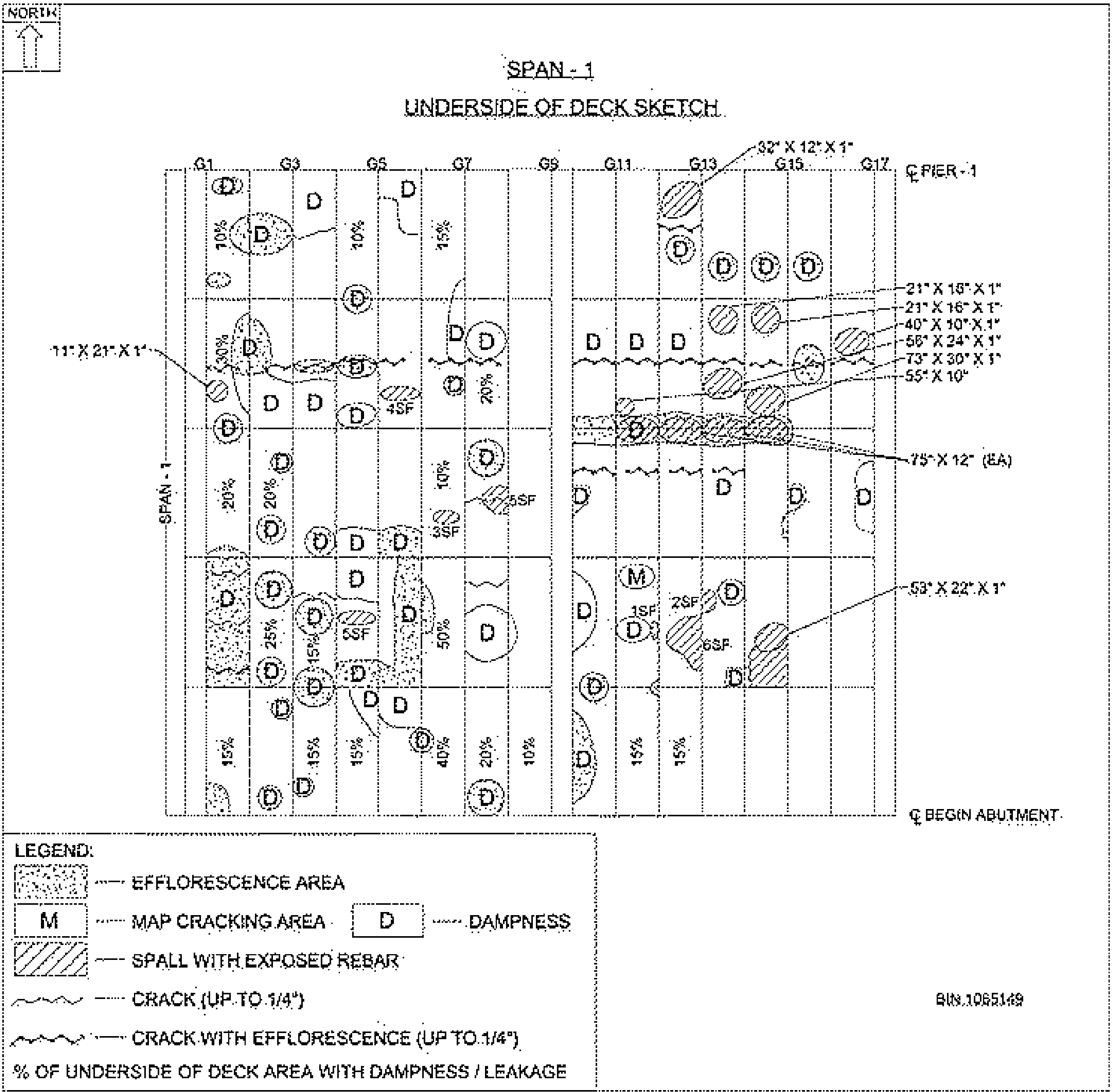
Sketch Description: Special Emphasis Sketch (2 of 3)

Sketch Number: **5** Sketch Filename: **Special Emphasis Sketch 3_3.jpg**



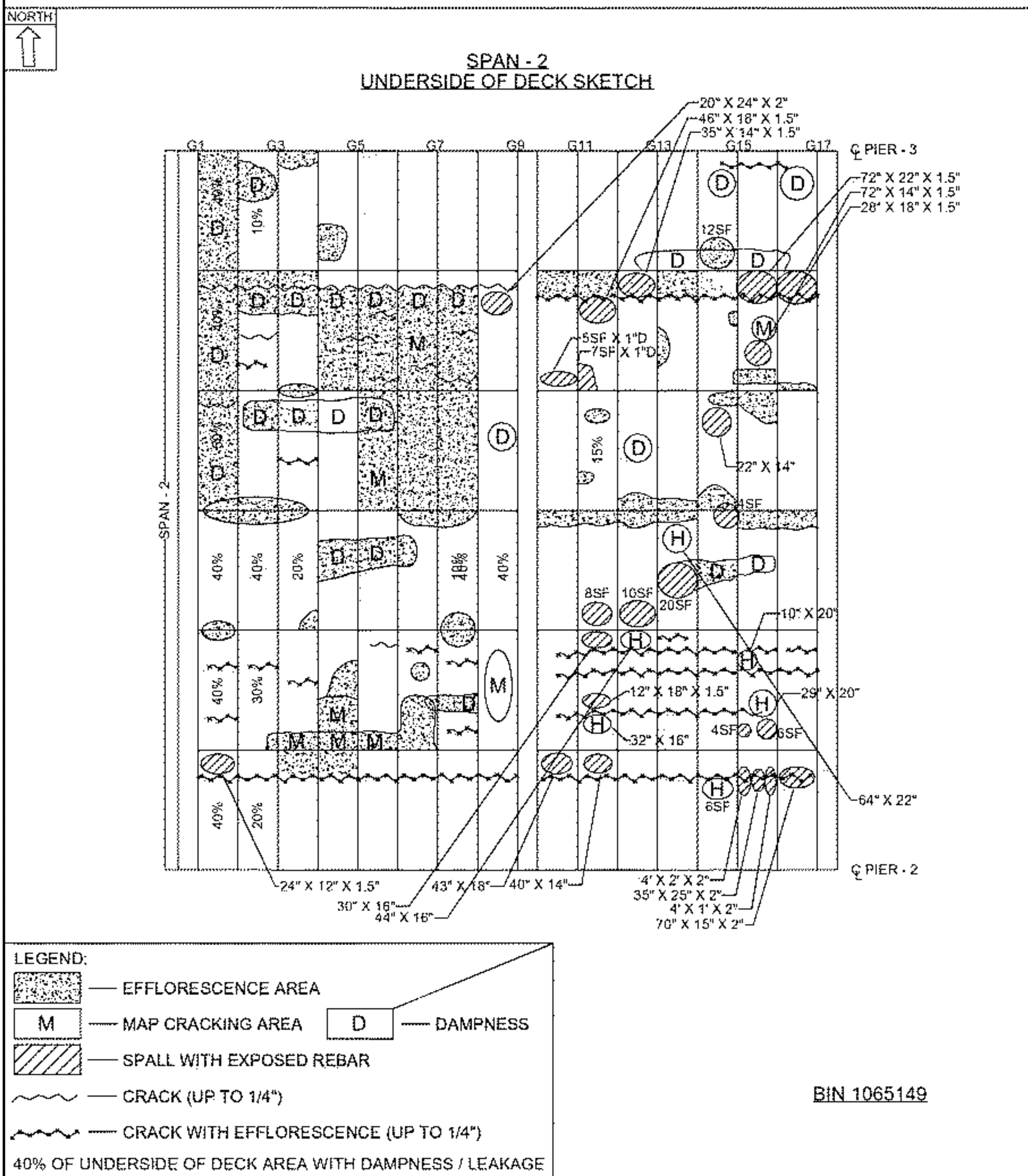
Sketch Description: Special Emphasis Sketch (3 of 3)

Sketch Number: **6** Sketch Filename: **Span 1 Underside of Deck Sketch.jpg**



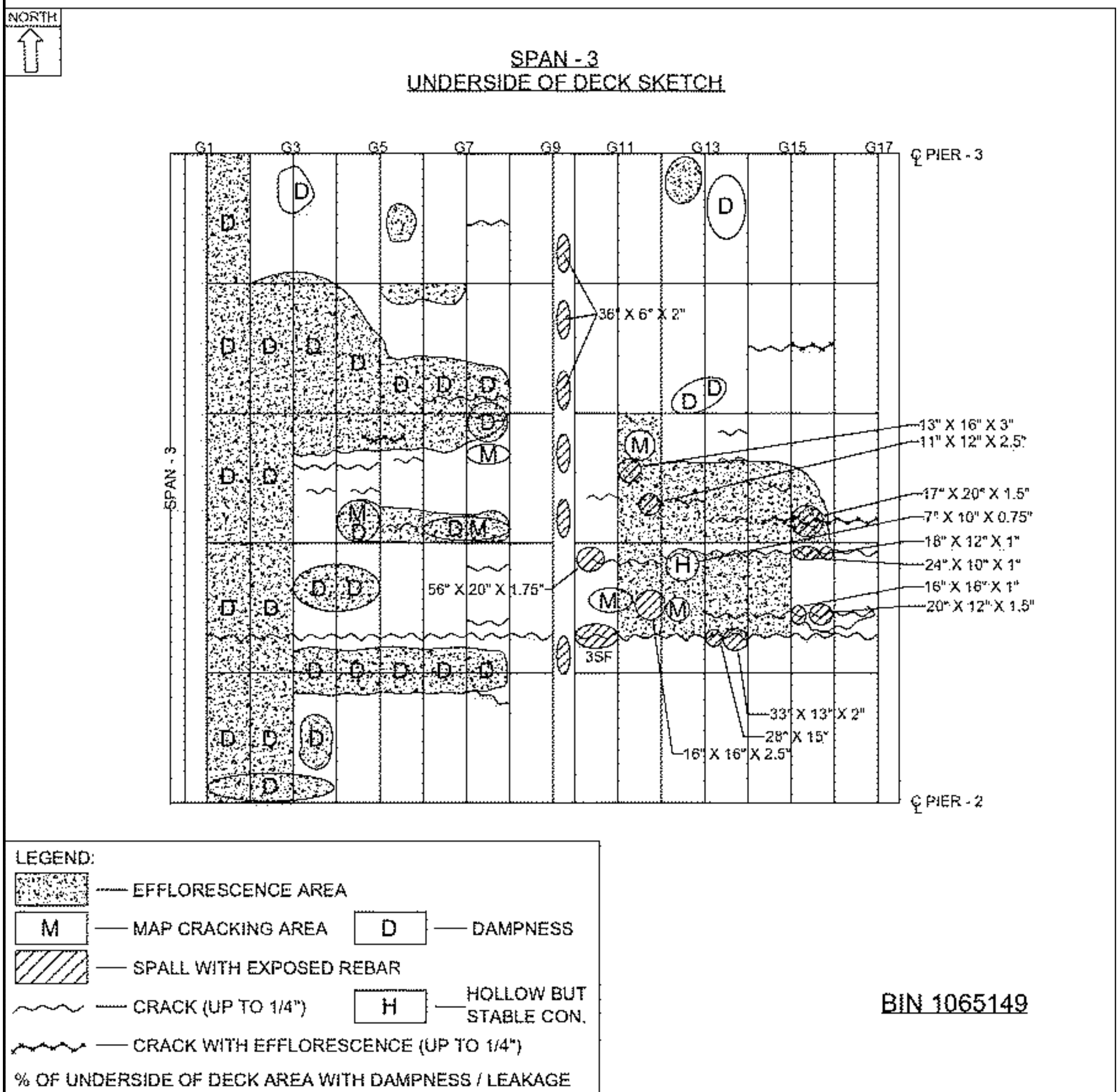
Sketch Description: Span 1 Underside of Deck Sketch

Sketch Number: **7** Sketch Filename: **Span 2 Underside of Deck Sketch.jpg**



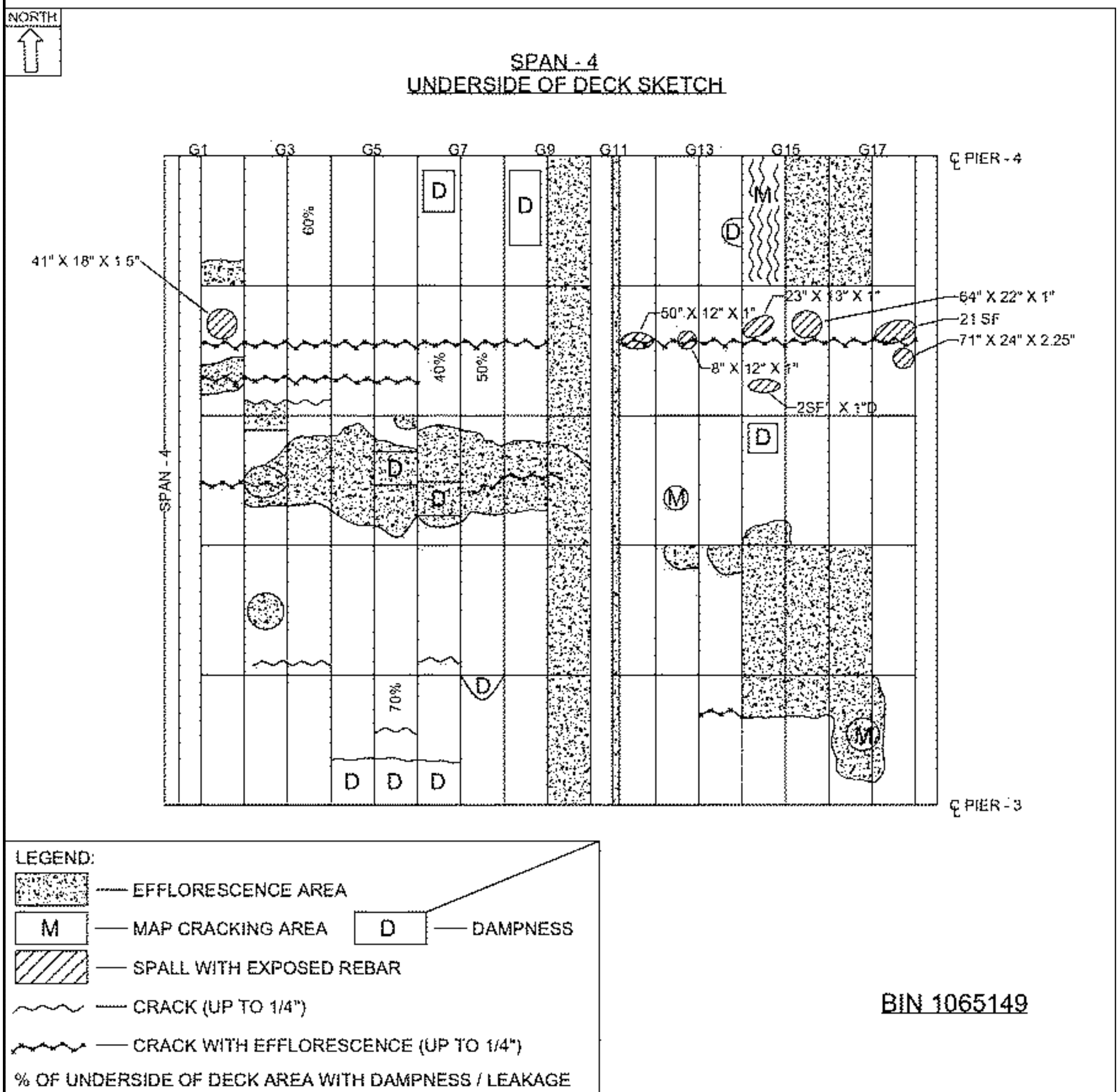
Sketch Description: Span 2 Underside of Deck Sketch

Sketch Number: **8** Sketch Filename: **Span 3 Underside of Deck Sketch.jpg**



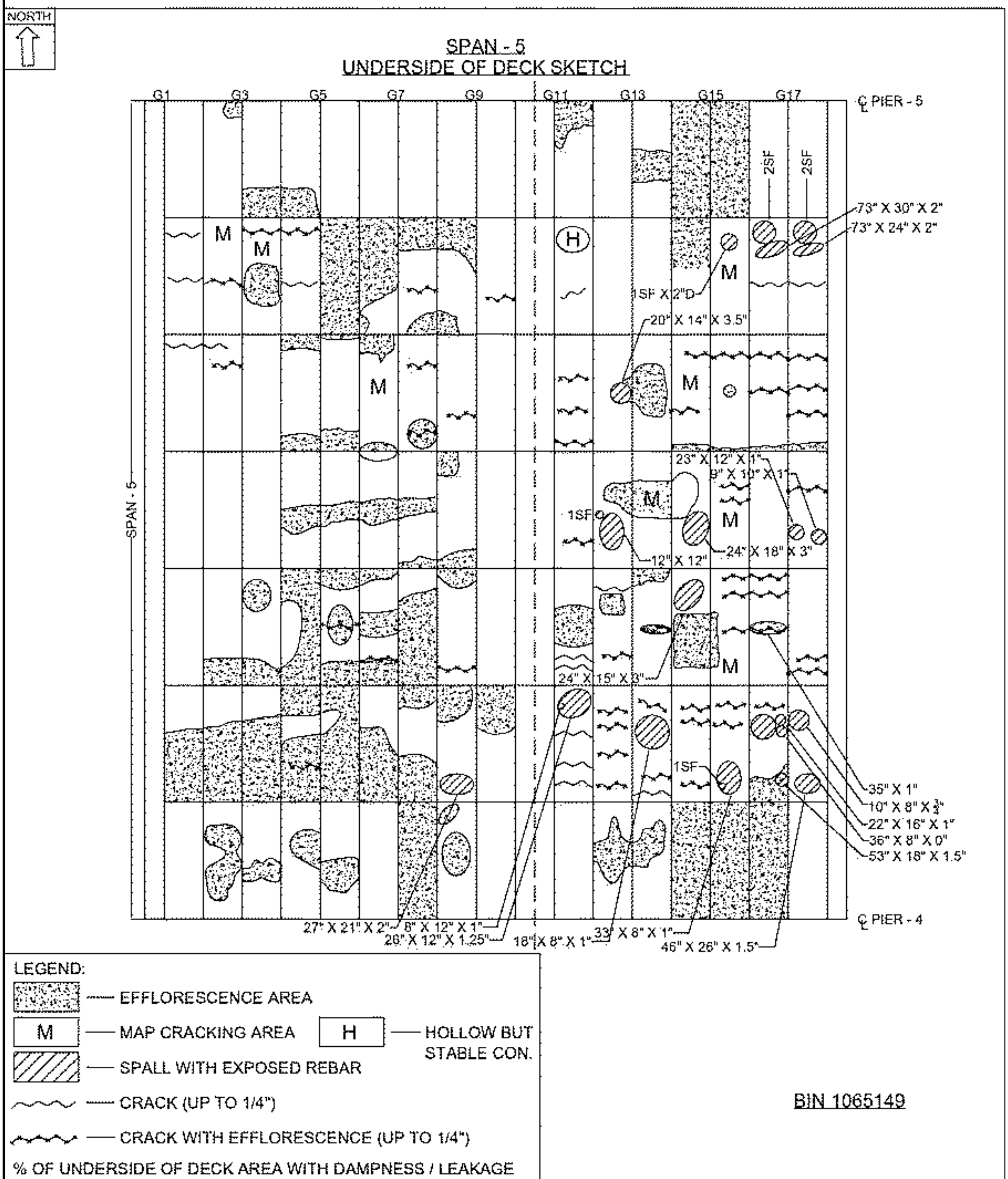
Sketch Description: Span 3 Underside of Deck Sketch

Sketch Number: **9** Sketch Filename: **Span 4 Underside of Deck Sketch.jpg**



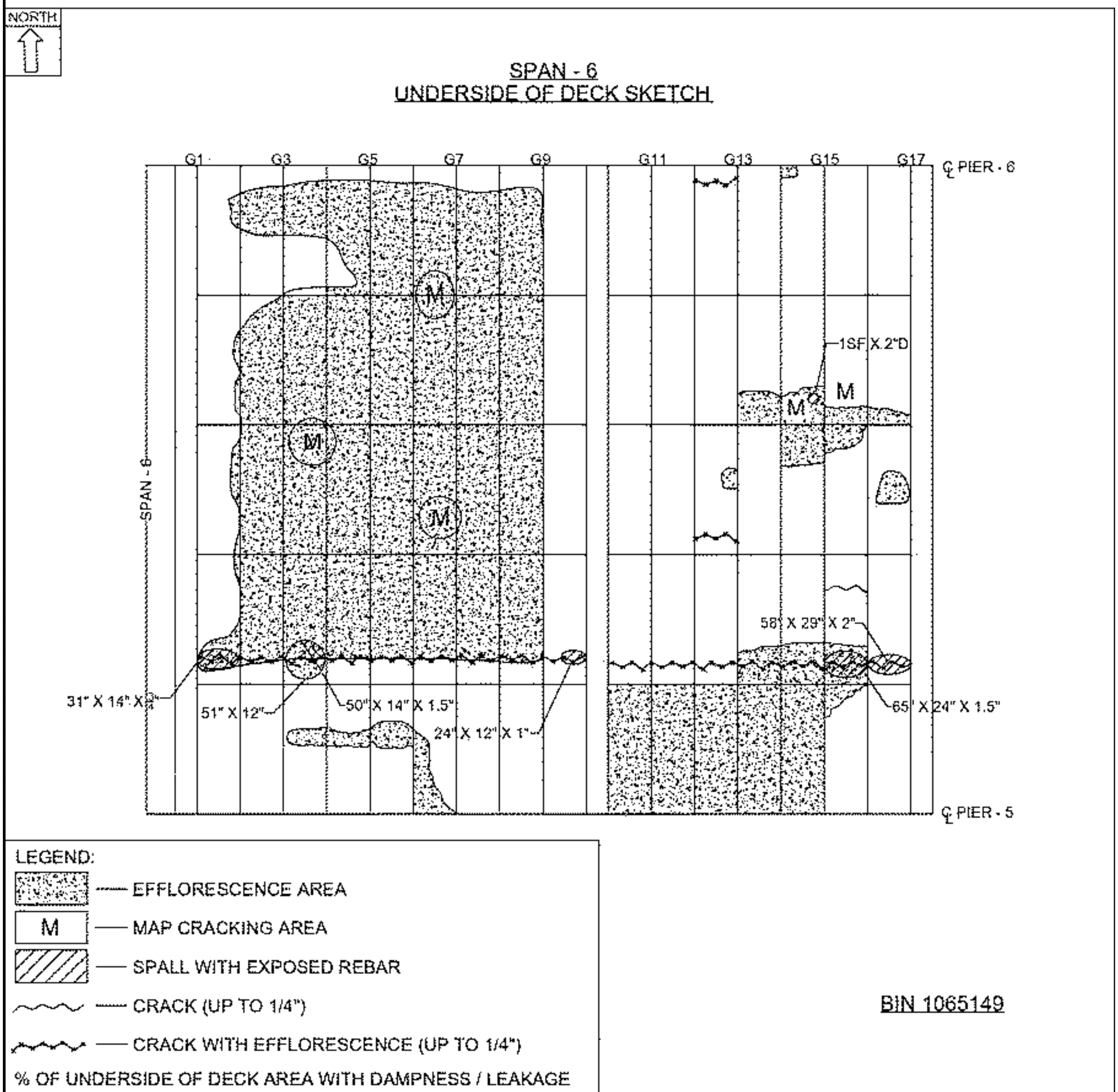
Sketch Description: Span 4 Underside of Deck Sketch

Sketch Number: **10** Sketch Filename: **Span 5 Underside of Deck Sketch.jpg**



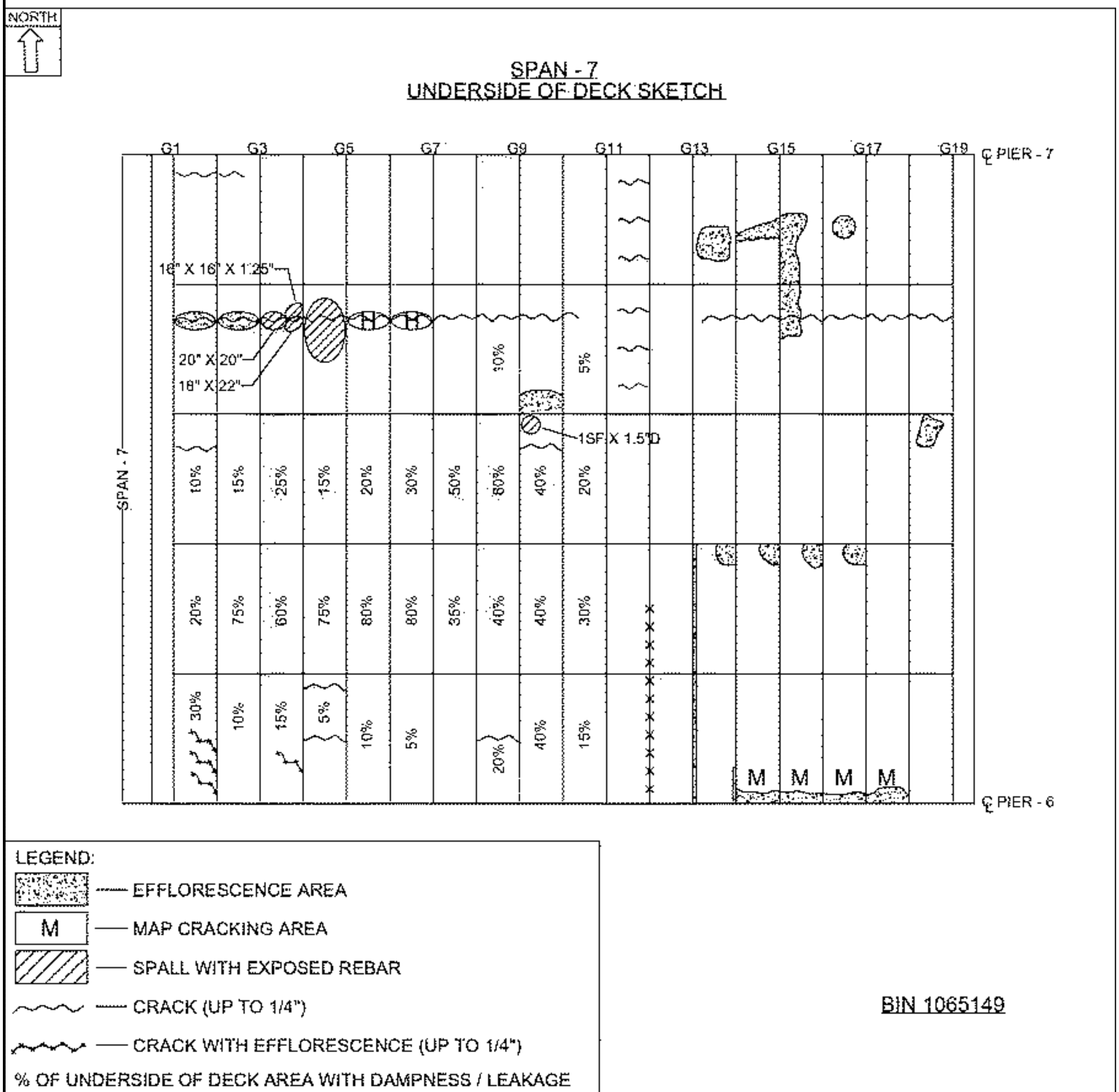
Sketch Description: Span 5 Underside of Deck Sketch

Sketch Number: **11** Sketch Filename: **Span 6 Underside of Deck Sketch.jpg**



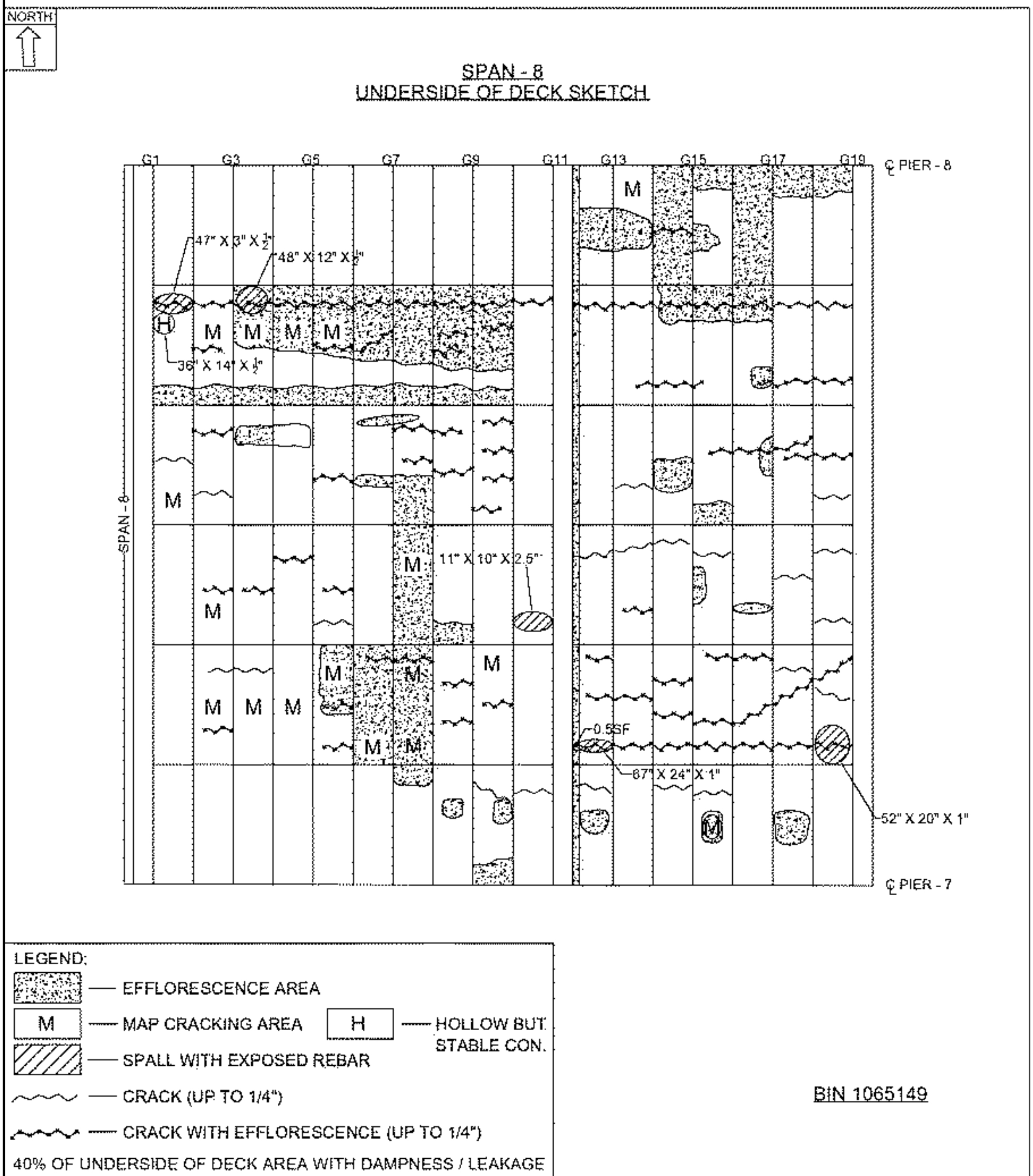
Sketch Description: Span 6 Underside of Deck Sketch

Sketch Number: **12** Sketch Filename: **Span 7 Underside of Deck Sketch.jpg**



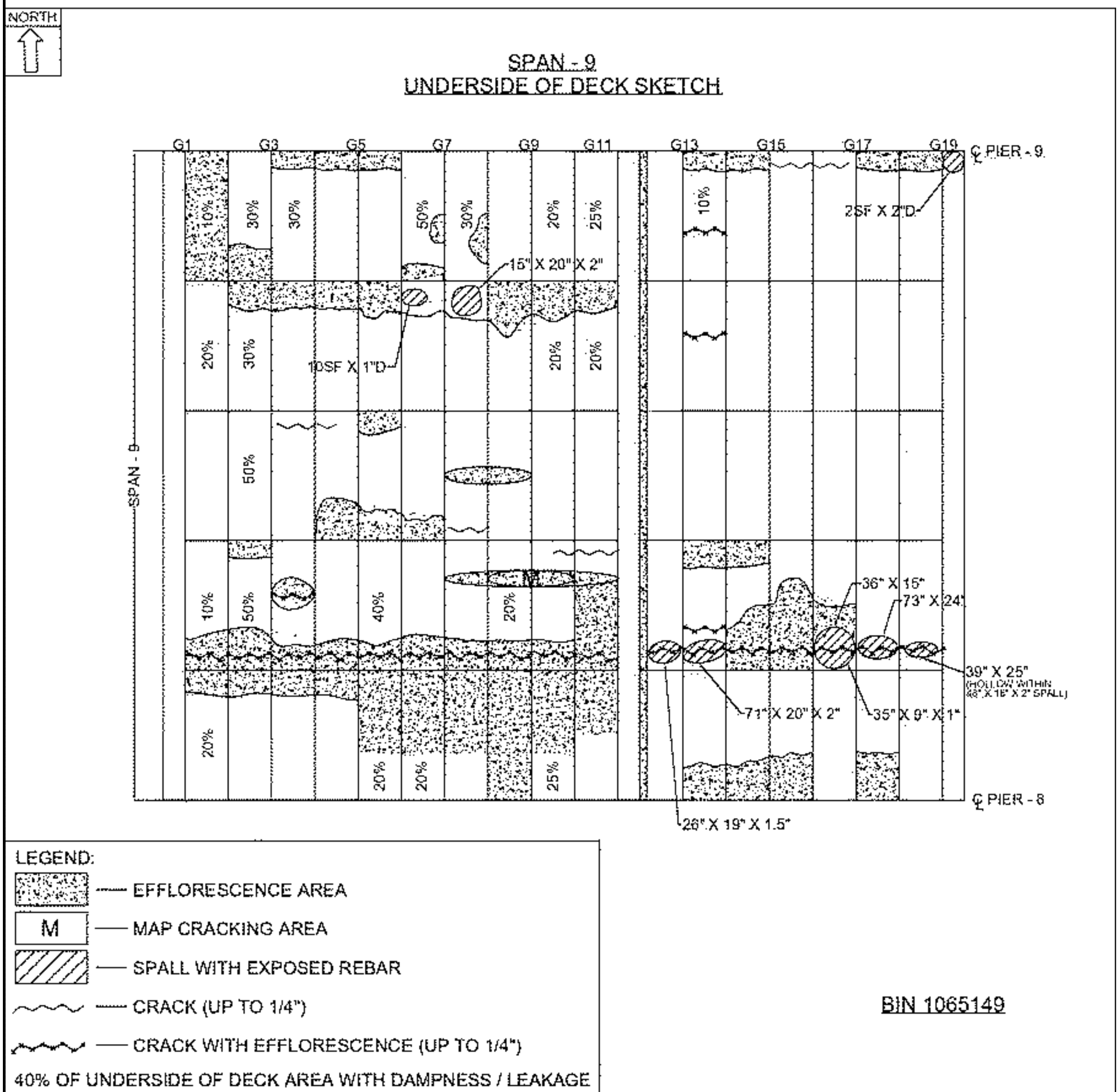
Sketch Description: Span 7 Underside of Deck Sketch

Sketch Number: **13** Sketch Filename: **Span 8 Underside of Deck Sketch.jpg**



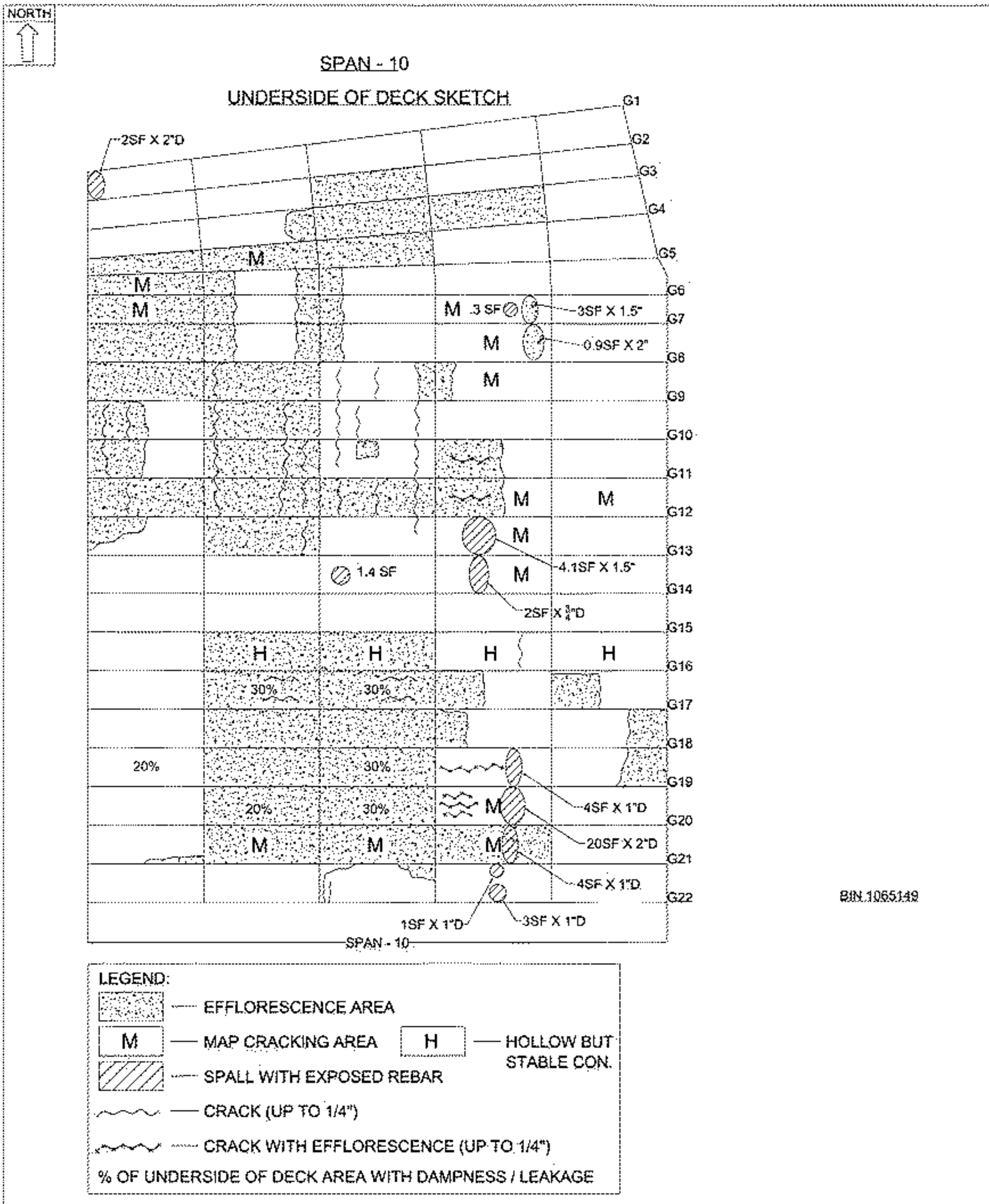
Sketch Description: Span 8 Underside of Deck Sketch

Sketch Number: **14**	Sketch Filename: **Span 9 Underside of Deck Sketch.jpg**



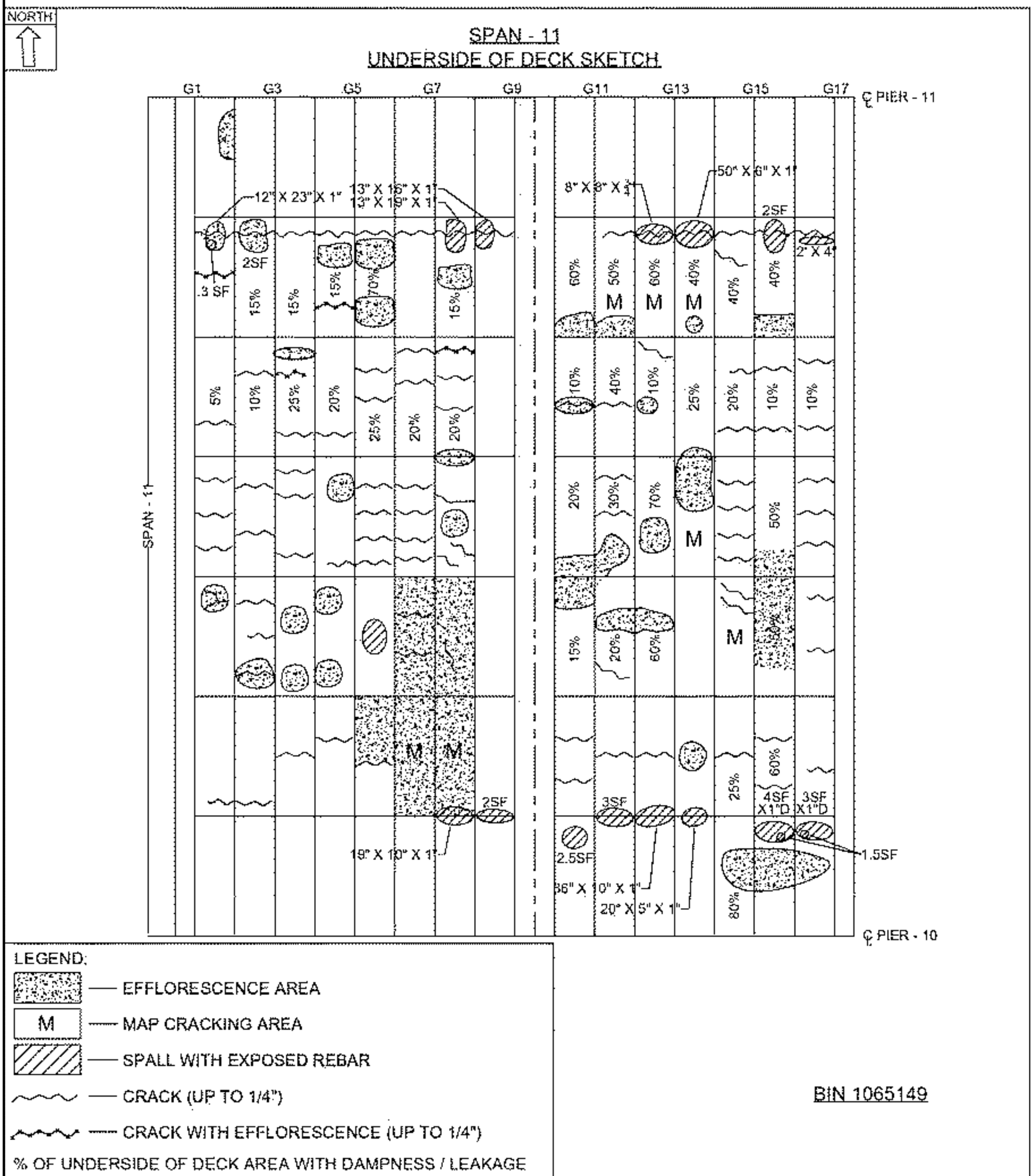
Sketch Description: Span 9 Underside of Deck Sketch

Sketch Number: **15** Sketch Filename: **Span 10 Underside of Deck Sketch.jpg**



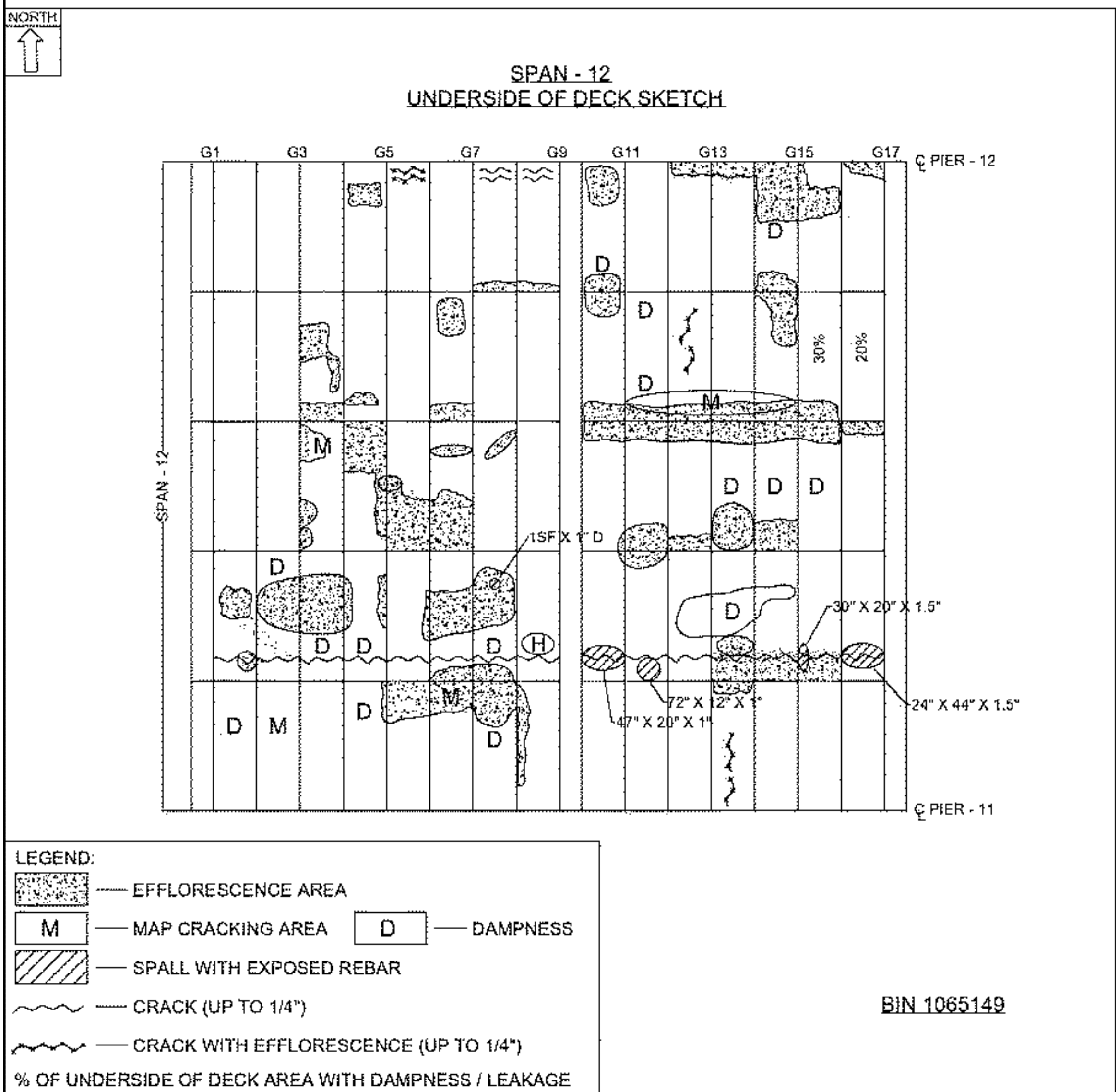
Sketch Description: Span 10 Underside of Deck Sketch

Sketch Number: **16** Sketch Filename: **Span 11 Underside of Deck Sketch.jpg**



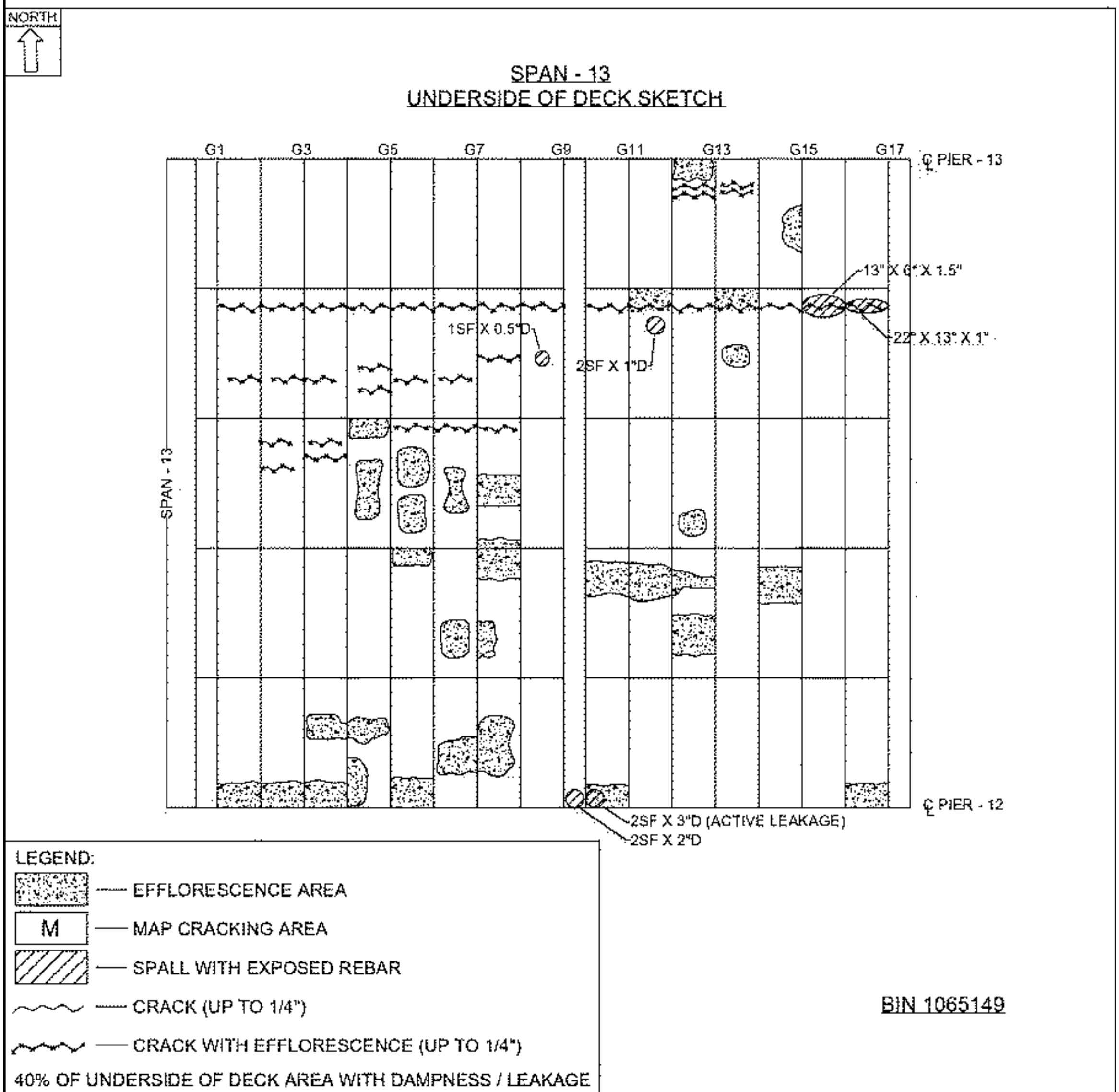
Sketch Description: Span 11 Underside of Deck Sketch

Sketch Number: **17** Sketch Filename: **Span 12 Underside of Deck Sketch.jpg**



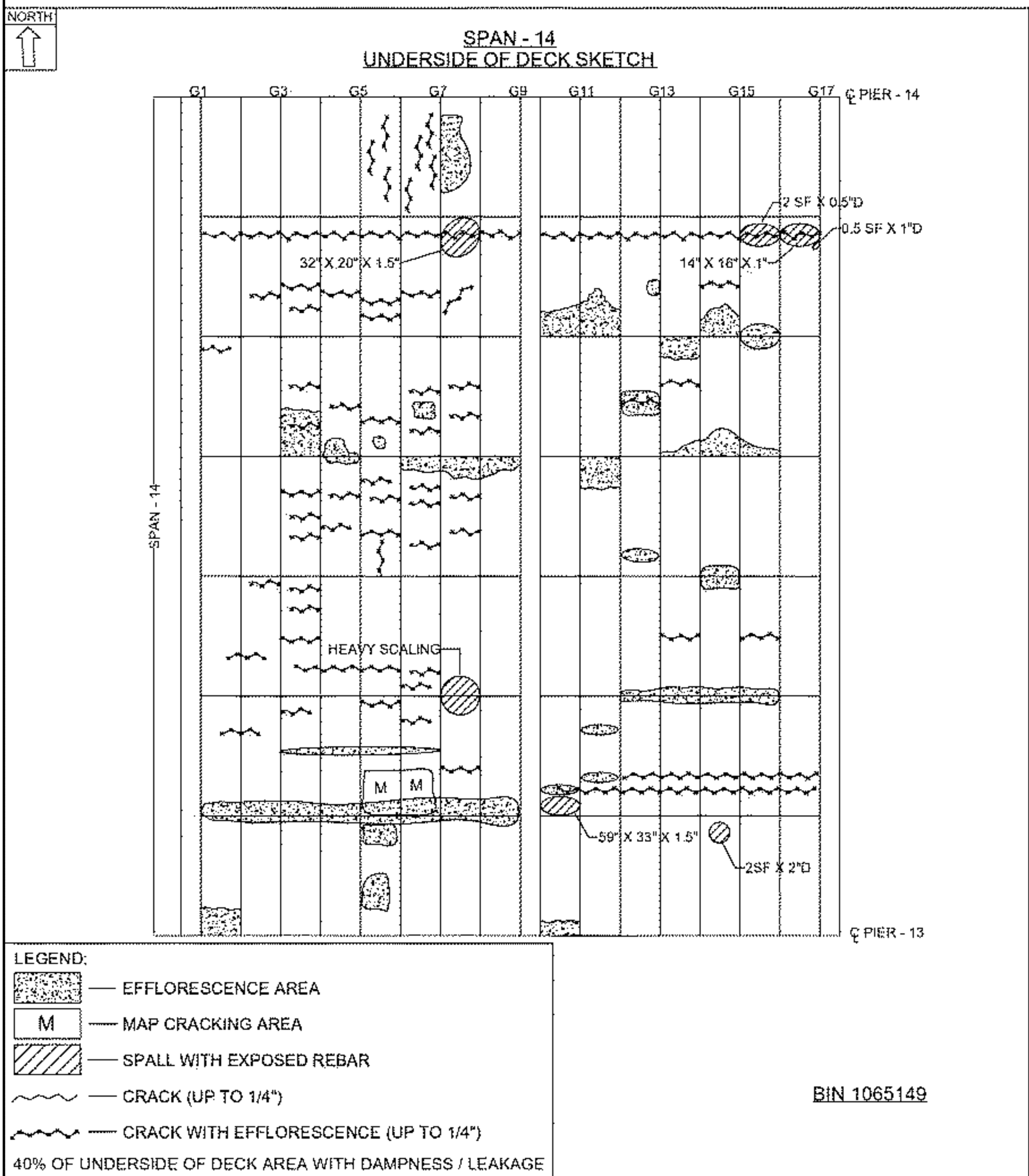
Sketch Description: Span 12 Underside of Deck Sketch

Sketch Number: **18** Sketch Filename: **Span 13 Underside of Deck Sketch.jpg**



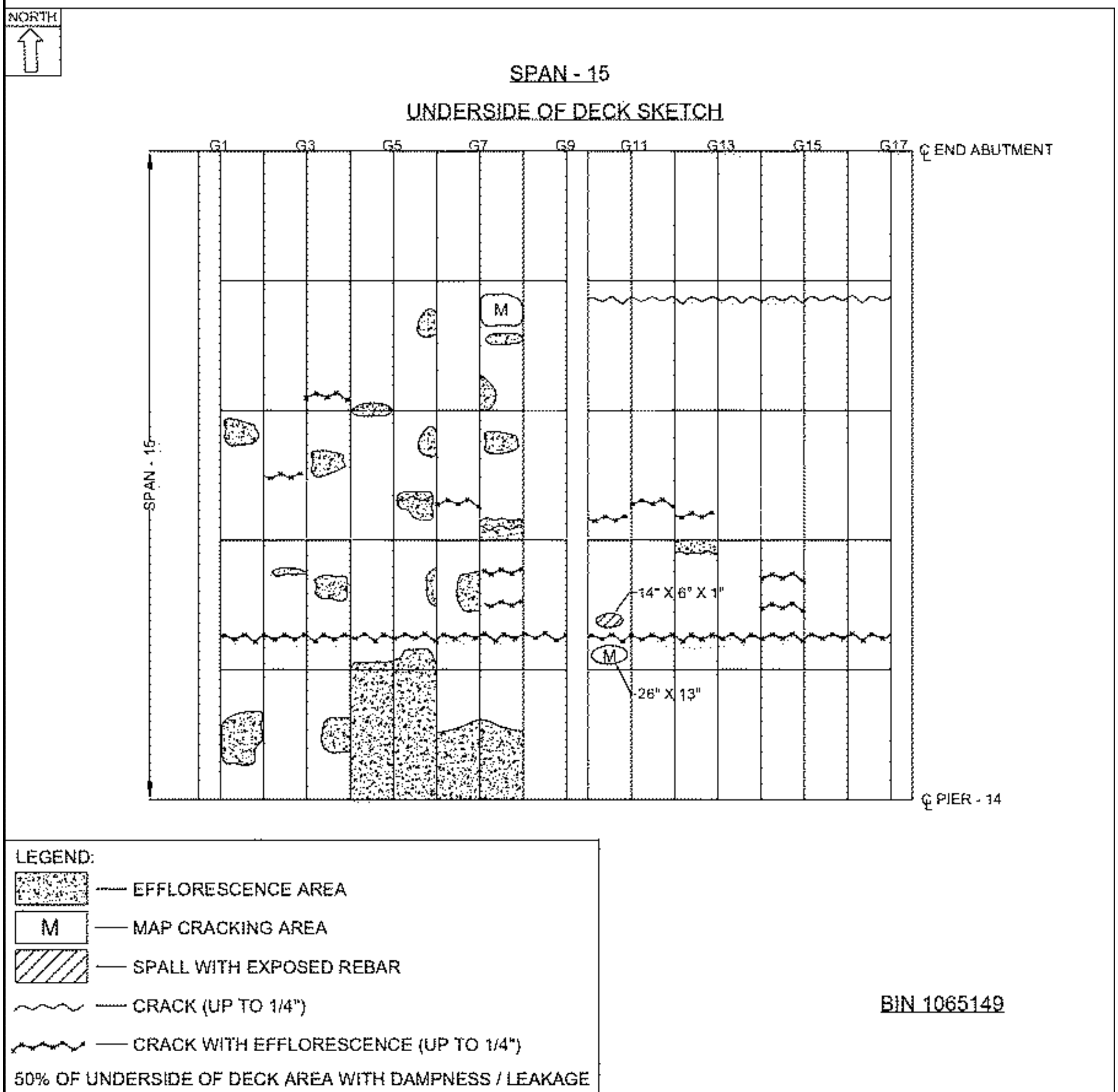
Sketch Description: Span 13 Underside of Deck Sketch

Sketch Number: **19**	Sketch Filename: **Span 14 Underside of Deck Sketch.jpg**



Sketch Description: Span 14 Underside of Deck Sketch

Sketch Number: **20** Sketch Filename: **Span 15 Underside of Deck Sketch.jpg**

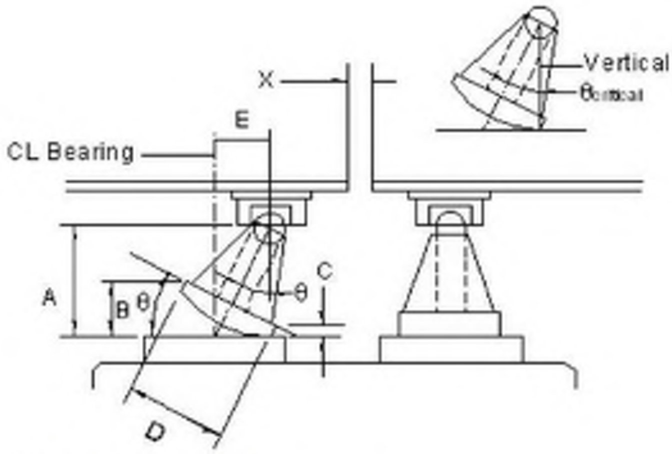


Sketch Description: Span 15 Underside of Deck Sketch

Sketch Number: **21** Sketch Filename: **20_Pier6-HighRockerBearings.jpg**

Insp. Date:	5/15/2020		**BIN:**	1065149

Inspection and Monitoring Requirements for High Rocker Bearings



Rocker Bearing Field Documentation Summary

1. Reference Sketch:
   - A = Height of rocker
   - B = High corner of rocker plate
   - C = Low corner of rocker plate
   - D = width of rocker plate
   - θ = Angle of rotation (tilt)
   - E = Eccentricity (translation)
   - X = minimum clear distance between girders or from girder to abutment

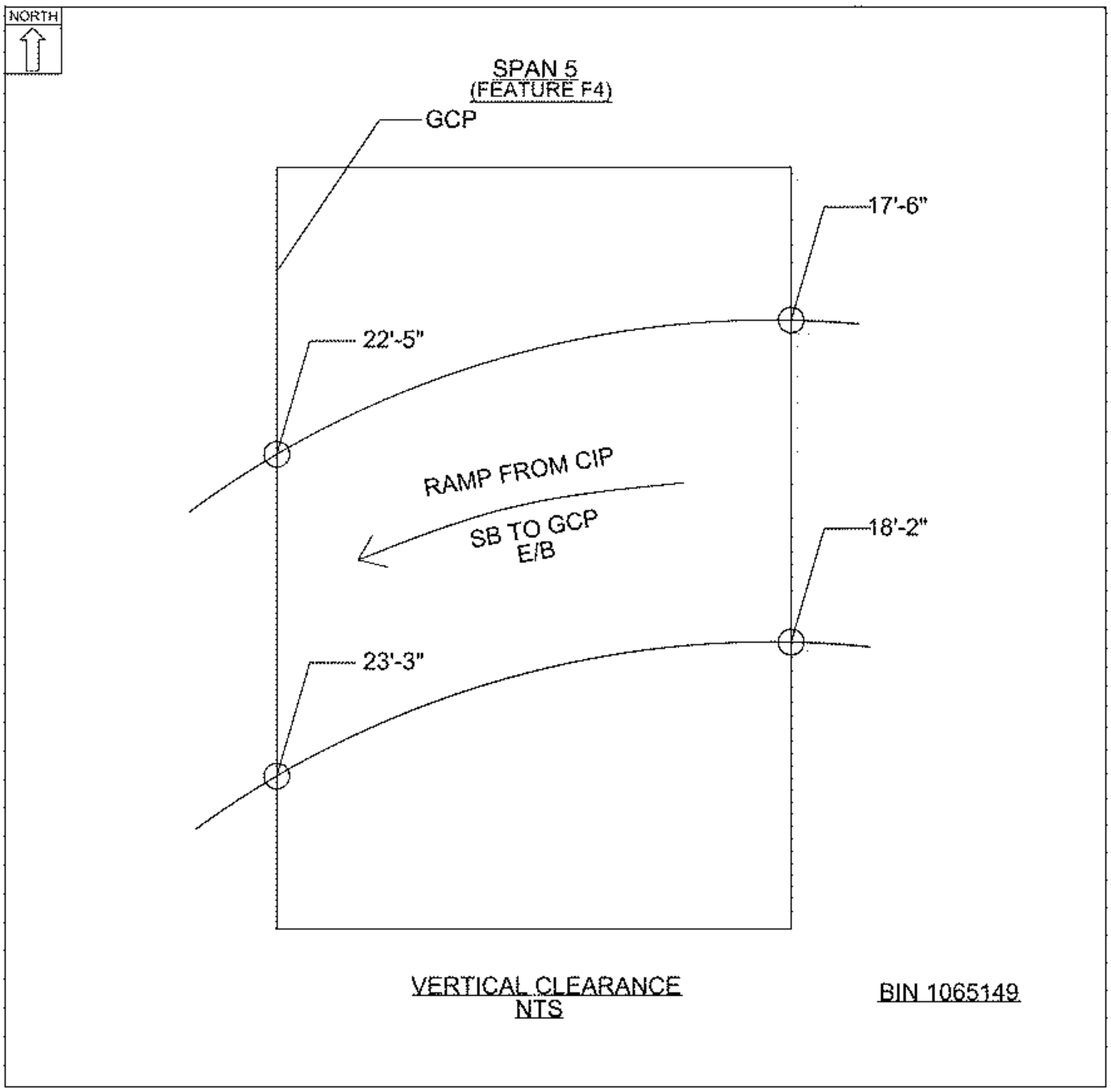
$\theta = \sin^{-1}(B-C)/D$ (Calculated)
$E = A \times \theta$ (Calculated), θ in Radians
$\theta_{critical}$: Limit of rotation-bearing pivot is vertical with edge of rocker.
$\theta_{critical} = \sin^{-1}(D/2)/A$ (Calculated)

Note: Dimensions are in inches.
Angles are in degrees

Date	Bearing Location	Ambient Temp (°F)	Dim "A"	Dim "B"	Dim "C"	Dim "D"	Dim "X"	Angle "θ"	Dim "E"
4/22/2020	Pier 6, Span 6, G14	43	10"	2.75"	2"	8"	18"	6°	1"
4/22/2020	Pier 6, Span 6, G15	43	10.125"	2.625"	2 1/8"	8"	18"	4°	0.7"
4/22/2020	Pier 6, Span 6, G16	43	10.125"	2.625"	2 1/8"	8"	18"	4°	0.7"

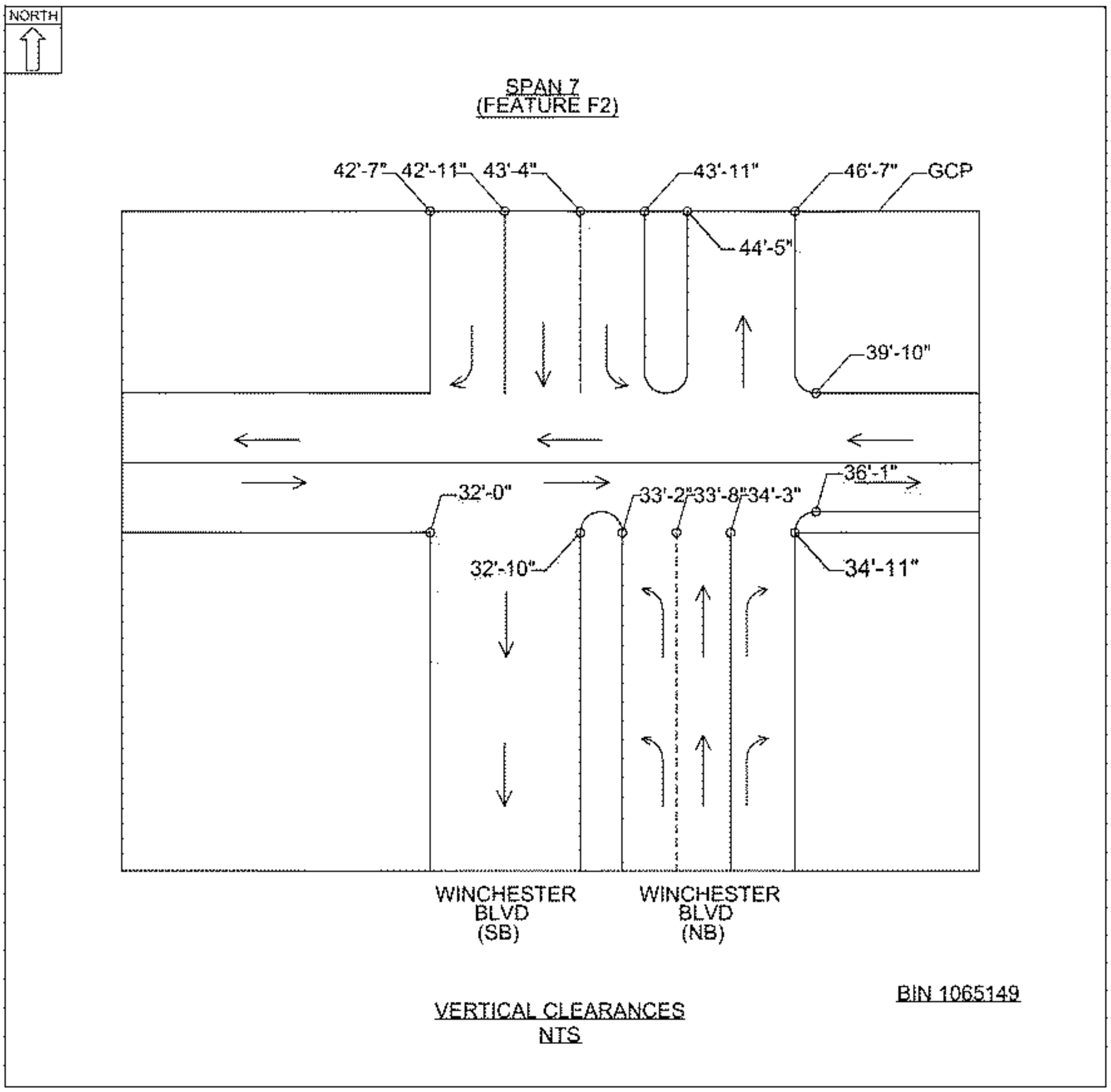
Sketch Description: 20_Pier 6 High Rocker Bearing Table

Sketch Number: **22**	Sketch Filename: **Span 5 VC.jpg**



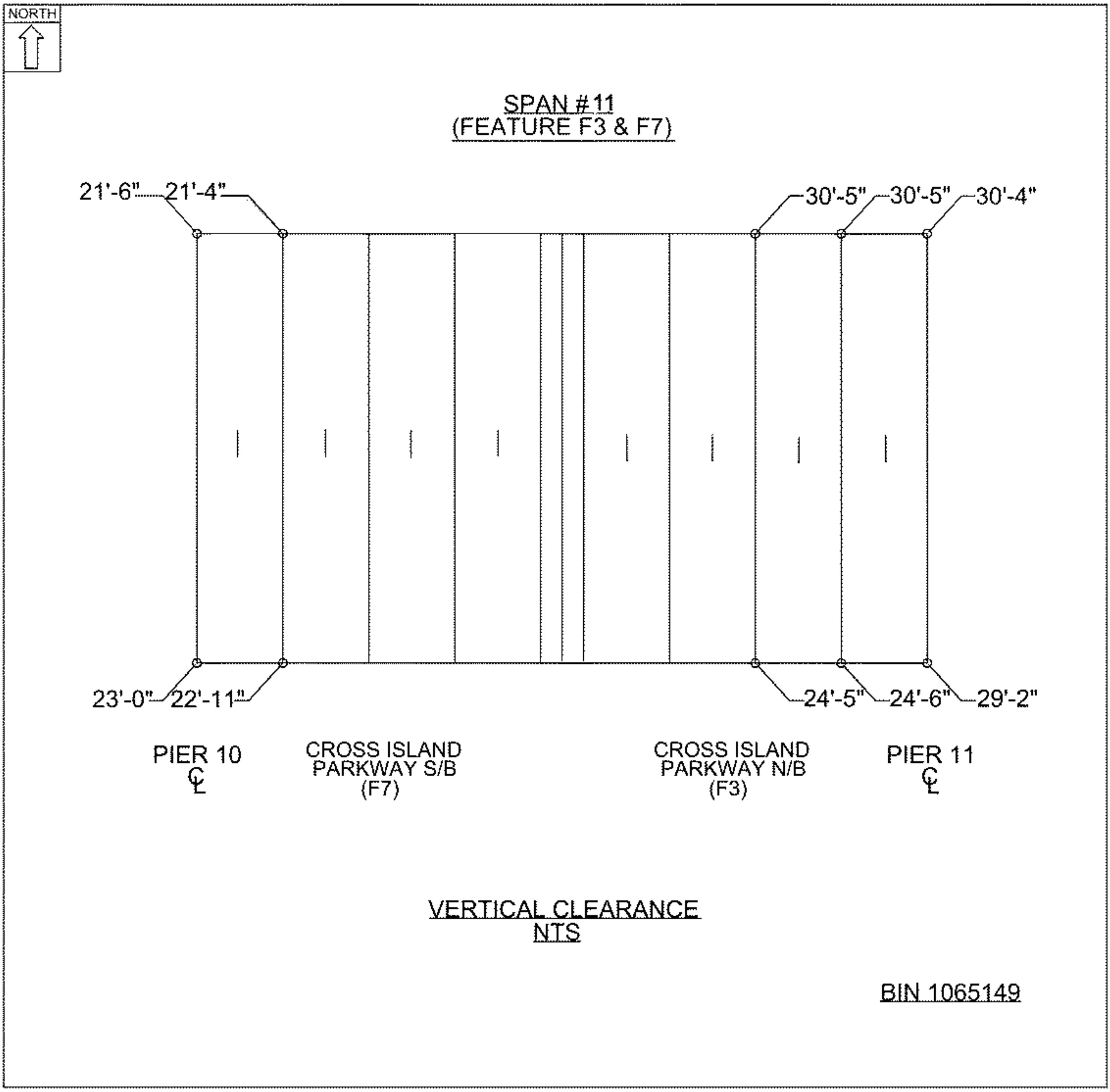
Sketch Description: Span 5 Vertical Clearances

Sketch Number: **23** Sketch Filename: **Span 7 VC.jpg**



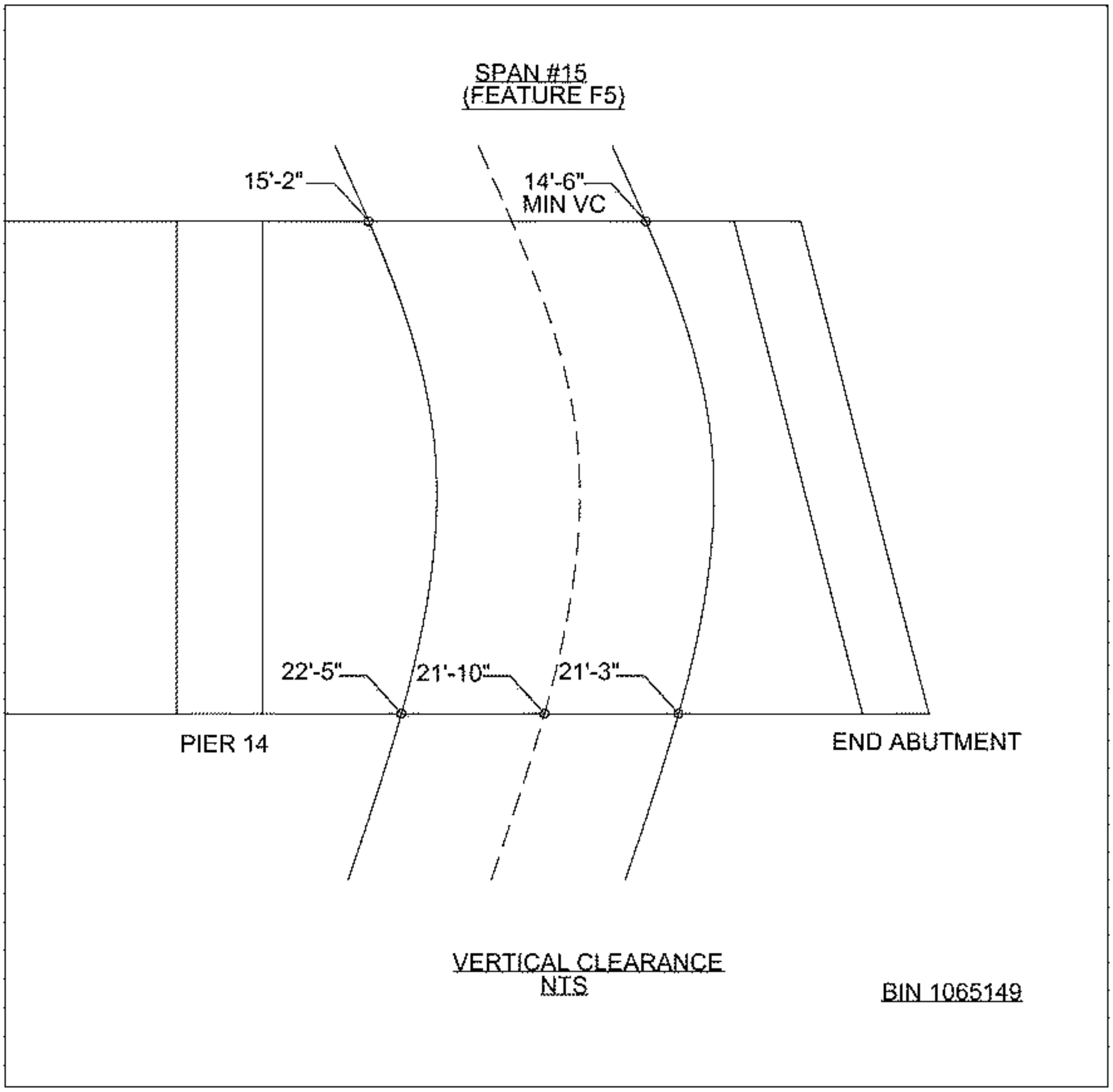
Sketch Description: Span 7 Vertical Clearances

Sketch Number: **24** Sketch Filename: **Span 11 VC.jpg**



Sketch Description: Span 11 Vertical Clearances

Sketch Number: **25**	Sketch Filename: **Span 15 VC.jpg**



Sketch Description: Span 15 Vertical Clearances

Sketch Number: **26** Sketch Filename: **2020 JMRR for BIN 1065149-001.jpg**

Worksheet
Routine Joint Maintenance Repairs

BIN: 1065149 **Feature Carried:** 907M907MX5M14134 **Feature Crossed:** 907A907AX5M21126 **County:** Queens
Consultant: Stantec Consulting Services **Team Leader:** Steve Wallin **Date:** 5/15/2020 **Temp (°F):** 65
Total Spans: 15

Abutment / Pier #	Direction (E/B, W/B, N/B, S/B)	Estimated Quantity	Ref. Photo	Ref. Sketch	Joint Description & Condition Codes	Comments
Piers 3 & 12	E/B & W/B	16'	 Pier 12 E/B (Typical)	N/A	Joint Description: Finger Plate Joint Condition Code: 5. Debris Filled	CS3
Piers 6 & 9	E/B & W/B	-	-	N/A	Joint Description: Finger Plate Joint 1. Sealer appears to be functioning / sealed properly / not damaged	-

Sketch Description: 2020 JMRR for BIN 1065149-001

Sketch Number: **27** Sketch Filename: **2020 JMRR for BIN 1065149-002.jpg**

Begin & End Abutment and Piers 1, 2, 4, 5, 7, 8, 10, 11, 13 & 14	E/B & W/B	-	-	-	-	No Joint

Estimated Year Joint Installed:
Estimated Design Life of Joint:

Condition Codes:

1. Sealer appears to be functioning / sealed properly / not damaged
2. Evidence of Leakage
3. Missing Sealer
4. Deteriorated Sealer
5. Debris Filled
6. Deteriorated Concrete Header
7. Deteriorated Armoring Angle
8. Concrete Header Spalls at Interface with Armor Angle

Guidelines:

Must enter code for every joint. Can use multiples codes when applicable. For joint with deficiencies provide the following: Estimate of quantity (feet) a typical photo for each condition code, sketch for unusual or complicated system, joint type (Filled Joint with Sealant, Filled Joint with Sealer, Sliding Plate, Finger Plate Joint, Armor Compression Seal, Strip Seal Joint, Modular Joint, Etc.)

2019-2020 General Inspection Queens County
Page 2 of 2

Sketch Description: 2020 JMRR for BIN 1065149-002

Sketch Number: **28** Sketch Filename: **20_Debris and Land Use Form-BD240.jpg**

BIN: 1065149 SHEET 1 OF 1

NEW YORK STATE DEPARTMENT OF TRANSPORTATION
BRIDGE INSPECTION REPORT

Under Bridge Debris Accumulation & Land Use Form

Created By:	Steven Wallin	Insp. Date:	5/15/2020

MOST CRITICAL Priority Rating (Select the appropriate Priority in the column below.)	
	H - High Priority (Condition Photos Required)
	M - Medium Priority
	L - Low Priority
	Blank - No Debris or Land Use

Priority	Debris	Spans	Remarks (Optional)
	01 - Containers, Marked		
	02 - Containers, Unmarked		
	03 - Non-Containerized		
	04 - Wood, Dwellings		
	05 - Wood, Heavy		
	06 - Wood, Light		
	07 - Metal		
	08 - Rubber, Plastics, Synthetics		
	09 - Asbestos Supposition		
L	10 - General Trash	3,6,9,12	Dirt and debris on Piers 3,6,9,12 below finger joints.
Priority	**Land Use Category**	**Spans**	**Remarks (Optional)**
	20 - Buildings, Ind./Comm. Fuel Storage		
	21 - Buildings, Ind./Comm. Non-Fuel Storage		
	22 - Buildings, Other		
	23 - Buildings, Parking Facilities		
	24 - Buildings, Electrical Facilities		
	25 - Attachments/Supports		

Instructions:

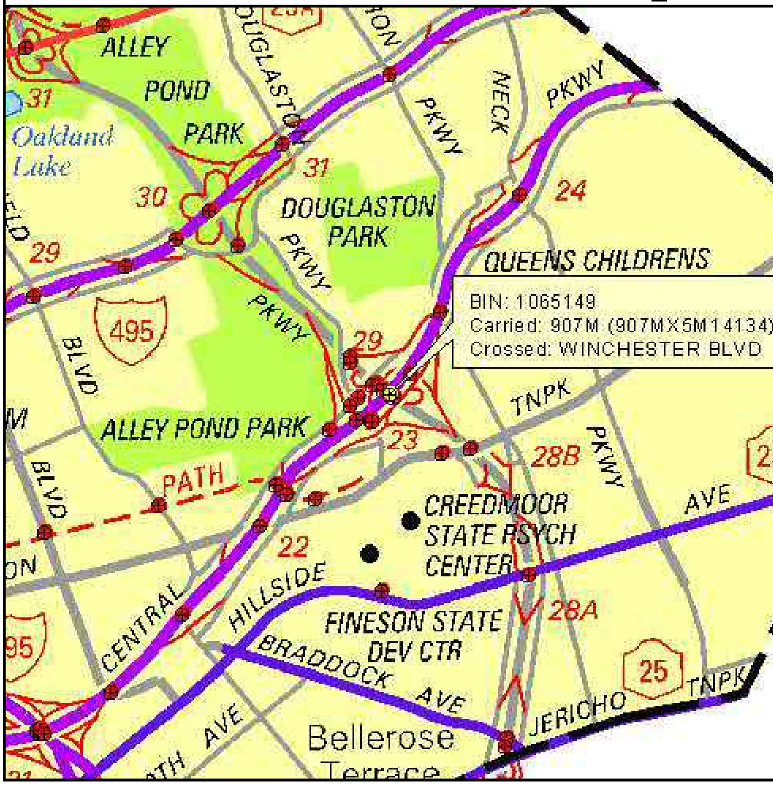
1. Select applicable Debris or Land Use Category Priority from dropdown.
2. Enter only the span or spans affected by debris, stored materials and/or land use.
3. If any Priority set to H, M or L, save completed page 1 as JPG file and attach as sketch to BDIS.
4. If any Priority set to H, M or L, save updated PDF to Templates and Files in BDIS.

BD240 (6/16)

Sketch Description: 20_Debris and Land Use Form-BD240

Standard Photographs

1065149_LOCATION_MAP.JPG



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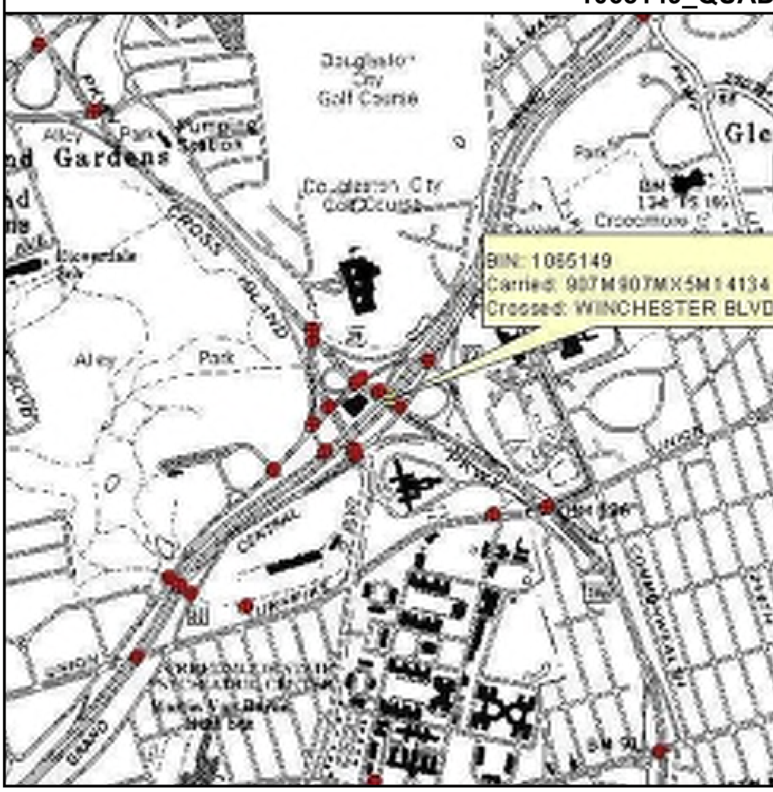
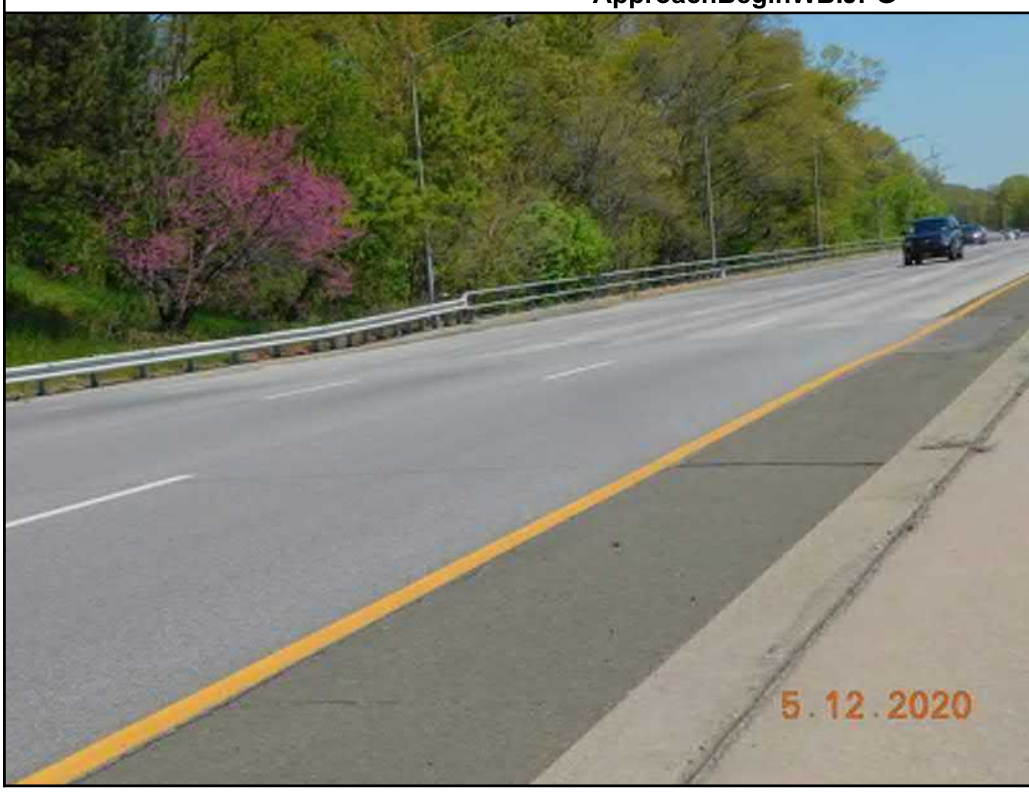


Abutment_Begin.JPG

Abutment_End.JPG

ApproachBeginEB.JPG

ApproachBeginWB.JPG



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ApproachEndWB.JPG

Begin_Left_Wingwall.JPG

ElevationLeftSpans11to13.JPG

ElevationLeftSpans14to15.JPG

ElevationLeftSpans6to10.JPG

ElevationRightSpans10-15.JPG

ElevationRightSpans12to13.JPG

ElevationRightSpans1to4.JPG

ElevationRightSpans4to7.JPG

ElevationRightSpans7to9.JPG

F2CrossedSpan7Left.JPG

F2CrossedSpan7Right.JPG

F3F7CrossedSpan11Left.JPG

F3F7CrossedSpan11Right.JPG

F4CrossedSpan5Left.JPG

F4CrossedSpan5Right.JPG

F5CrossedSpan15Left.JPG

F5CrossedSpan15Right.JPG

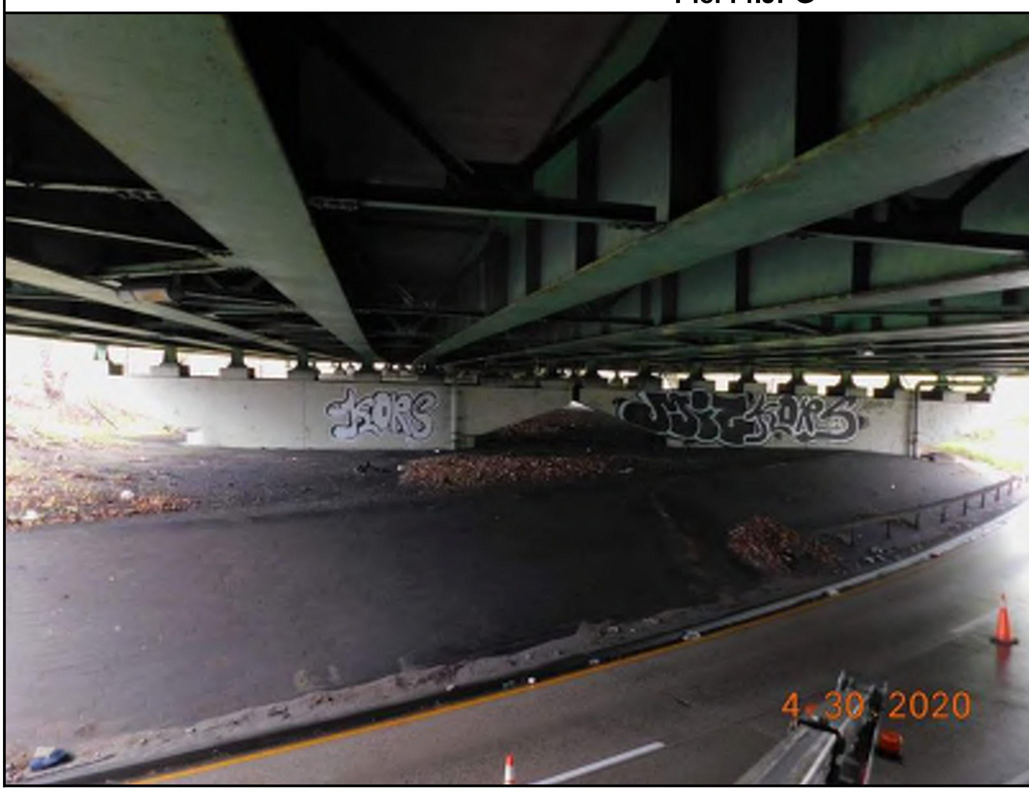
F6CrossedSpan2to6Ahead.JPG

F6CrossedSpan2to6Back.JPG

F6CrossedSpan2to6Left.JPG

Framing_Span_2.JPG

Pier14.JPG



Pier_1.JPG

Pier_3.JPG

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GRAND CENTRAL PARKWAY DECK REHABILITATION

BIN 1065149 Carrying Grand Central Parkway over Cross Island Parkway and Winchester Boulevard and BIN 106514A Carrying Grand Central Parkway Ramp H over Cross Island Parkway

QUEENS COUNTY, NEW YORK
NON-DESTRUCTUVE TESTING

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VCS Project Number – M21041NY
November 2, 2021

Introduction

BIN 1065149 and BIN 106514A are located in Queens County, New York (Figure 1). BIN 1065149 carries the Grand Central Parkway over the Cross Island Parkway and Winchester Boulevard. BIN 1065149, also referred to as Ramp H, carries the Grand Central Parkway over the Cross Island Parkway. The bridges were constructed between 1970-1972 and have a cast-in-place reinforced concrete deck that is supported by steel girders and cast-in-place reinforced concrete piers. There are 15 spans associated with BIN 1065149 with 3 eastbound (EB) and 3 westbound (WB) lanes, and 1 span associated with BIN 106514A that has 2 lanes connecting to the WB lanes of BIN 1065149.

The bridge deck is exhibiting visual signs of deterioration in the form of concrete cracking and delamination. The top surface of deck consists of numerous deck patches that have been completed through various generations of repairs and some are exhibiting cracking and delamination. CHA Consulting, Inc. is evaluating the possibility of rehabilitating the decks of BIN 1065149 and BIN 106514A and has engaged NDT Corporation (NDT Corp.), a wholly-owned subsidiary of Vector Corrosion Services (VCS), to perform a non-destructive evaluation (NDE) of the bridge decks to assess their condition and potential rehabilitation options.

Figure 1: Overview of BIN 1065149 and BIN 106514A

Test Methods & Results

This section describes the methods used by NDT Corp. to investigate the condition of the ramps along with results from these methods. A detailed discussion regarding each result is provided with conclusions and recommendations.

The odd numbered spans were tested in the EB direction, and the even-numbered spans were tested in the WB direction. Testing was conducted in the slow lane (SL) and the high speed lane (HSL). A detailed map showing all the tested areas in each span is included in Appendix A.

Impact Echo/Pulse Velocity Testing

Impact echo/pulse velocity (IE/PV) testing is a non-destructive method used to determine concrete characteristics and identify delamination, cracking, and voids in concrete through the application of stress waves imparted to the concrete. The IE/PV impact device uses a small steel ball bearing which is impacted onto the concrete surface to create compressional, shear and surface waves. An array of sensors monitors the wave propagation through the concrete section measuring compressional and shear wave transmission velocities as well as reflected compressional waves (impact-echoes). The velocity of a stress wave through concrete is determined by the density, elastic modulus, Poisson's ratio of the concrete, as well as the presence of cracks or voids.

In concrete, transmission velocity values are used to calculate the average dynamic strength of concrete. Dynamic strength is affected by the amount of cracking in the concrete section. In sound concrete, sonic/ultrasonic wave velocity is around 13,000-15,000 ft/sec. However, in cracked concrete velocity is diminished since the waves have to travel around the cracks.

Delaminations are identified using the reflected (impact-echo) signals. Delaminations act like a drumhead and, when impacted, produce a low-frequency sound that, if the delamination is large enough, can be audible. IE measurements are far more sensitive than the human ear and can detect delaminations at an earlier stage. Due to the nature of a delamination (horizontal cracking/separation of the concrete) the signal becomes trapped in the surface layer and the condition of the concrete below the delamination cannot be determined.

The IE/PV data was acquired using an automated system developed by NDT Corp. (Figure 2). This system consists of an automated projectile impact energy source, together with four sensors spaced 0.5 ft, 2.0 ft, 2.5 ft and 3.5 ft from the projectile impact source. The system's sensors are configured in a "L" shape, which allows the device to detect cracks and delaminations in the X, Y, and Z axis as the tester moved along the travel lane (Figure 2 through Figure 4).

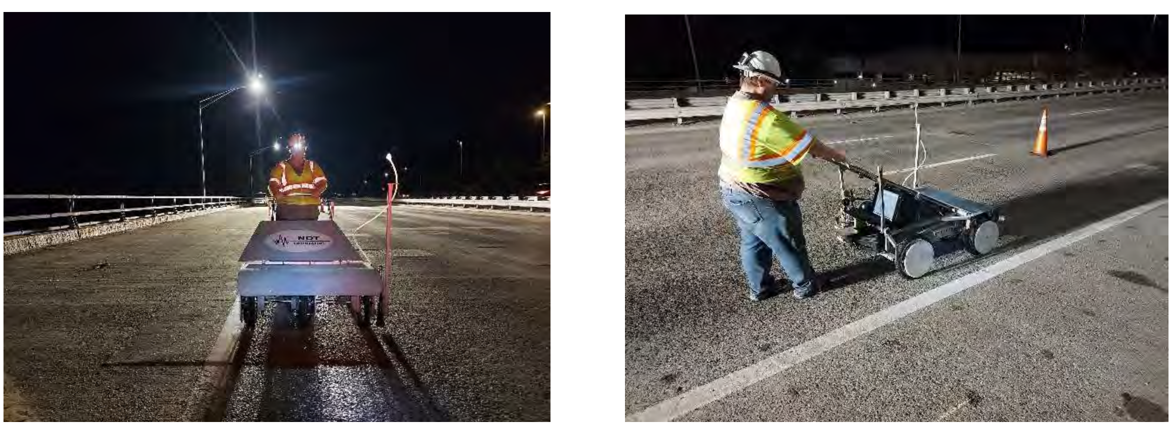

Figure 2: Automated Impact Echo/Pulse Velocity Tester

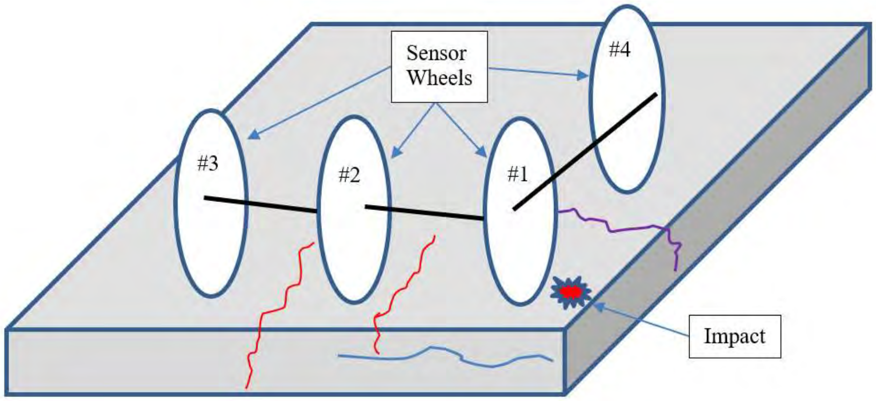

Figure 3: Automated Impact Echo/Pulse Velocity Sensor Configuration

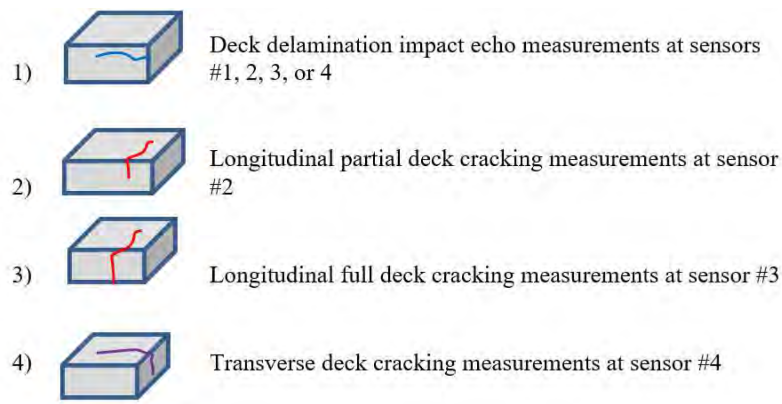

Figure 4: Automated Sensor Detection Capabilities

IE/PV survey maps for all the tested spans are presented in Appendix B, and select survey plots are shown in
Figure 5 through Figure 7. For most of the spans, delaminated areas exceeded 30% of the tested area (Table 1). Span 9 EB was in the best condition with only 5% delaminated area (
Figure 5), and Span 12 WB was in the worst condition with 72% delaminated area (Figure 7). 72% of delaminations for an area is excessive, and IE/PV testing may be overestimating this value. However, it is clear that the concrete in Span 12 WB has extensive deterioration. Figure 6 shows an IE/PV survey map that is typical for the majority of the spans. Overall, 41% of the area was delaminated, 19% of the area indicated the presence of cracking, and 40% was sound (Table 1). It should be noted that in the areas of delaminations and subsurface horizontal cracking, IE/PV testing is not able to detect the condition of the deck below the delamination/crack as the signal is not able to penetrate the crack boundary.

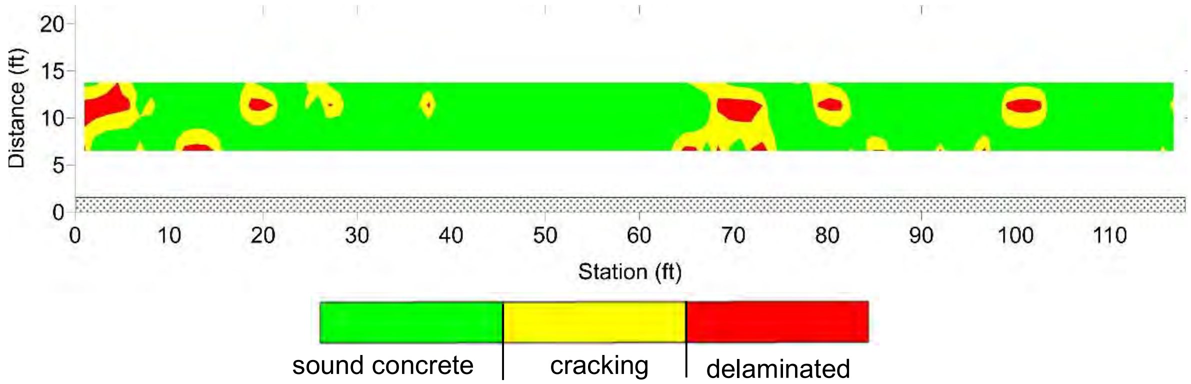

Figure 5: IE/PV Survey Map for Span 9 Eastbound Slow Lane

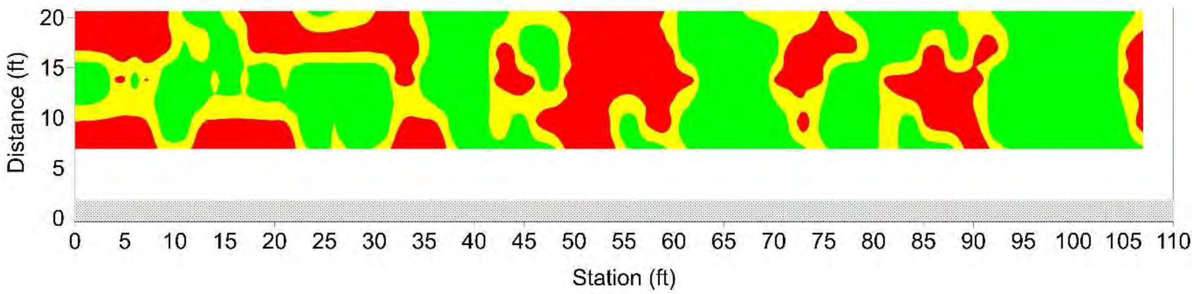

Figure 6: IE/PV Survey Map for Span 4 Westbound Slow Lane

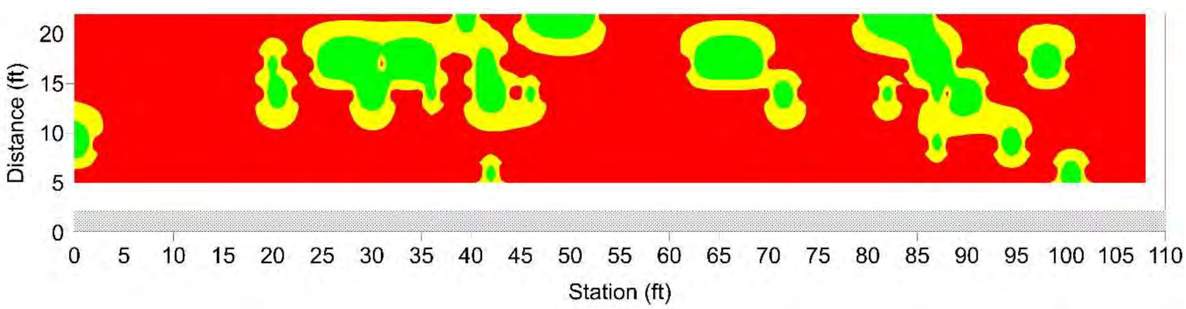

Figure 7: IE/PV Survey Map for Span 12 Westbound Slow Lane

Table 1: IE/PV Survey Summary

Span	Delaminated Area (%)	Area of Cracking (%)	Sound Concrete (%)
1EB HSL	40%	21%	38%
2WB HSL	59%	15%	26%
3EB SL	27%	24%	49%
4WB SL	32%	21%	47%
5EB SL	45%	26%	29%
6WB SL	51%	22%	27%
7EB SL	18%	10%	72%
8WB HSL	28%	24%	48%
9EB HSL	5%	13%	82%
10WB HSL	56%	21%	23%
11EB HSL	47%	26%	27%
12WB SL	72%	17%	11%
13EB HSL	36%	14%	50%
14WB SL	61%	18%	21%
15EB HSL	20%	14%	66%
Ramp H	31%	27%	41%
Overall	41%	19%	40%

Ground Penetrating Radar Survey

Ground penetrating radar (GPR) is a quick and effective way of identifying the location and depth of metal objects within reinforced concrete. Steel reinforcement can be easily identified in a GPR scan due to the significant difference in the electromagnetic properties of steel and concrete. As a result, the location and depth of steel elements (i.e. cover-depth) in concrete can be determined accurately and efficiently.

In addition to cover-depth, GPR is capable of identifying the qualitative condition of reinforced concrete elements. Analysis of the reinforcement's GPR reflection amplitudes can provide insight into the condition of the steel and the quality of the cover concrete. Attenuation of the GPR reflection waves is caused by increased concentrations of chlorides, moisture, presence of significant cracking, and other forms of physical concrete deterioration.

Figure 8 provides an example of GPR data collected on a reinforced concrete slab. The distinct white hyperbolas are the reflections of the GPR signal by the embedded steel reinforcement. The stronger the reflection the greater the amplitude and the brighter white it appears. Areas of deterioration have a weaker reflection and thus appear darker and faded.

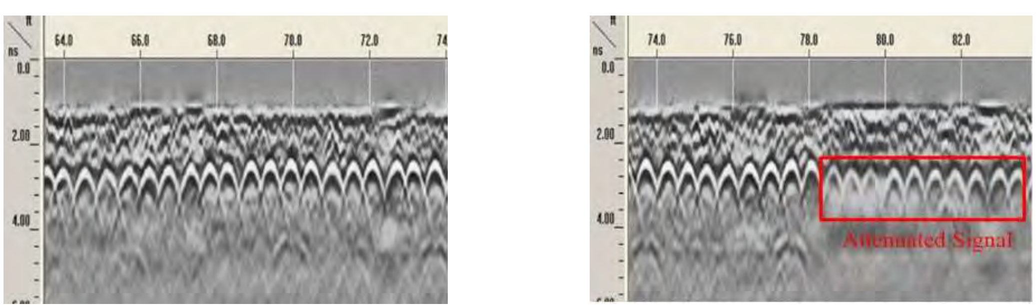

Figure 8: Attenuation of GPR Signal due to Deterioration of Concrete

Using this methodology, a reinforced concrete structure can be surveyed with GPR and the spatial distribution of the steel reflection amplitudes can be plotted. Areas of high attenuation indicate locations of concern for deterioration. These areas of attenuation indicate potential contamination or deterioration in the cover concrete and the top layer of reinforcing bars. This deterioration could just be high concentration of chlorides or moisture, which could lead to corrosion. Or it could be corrosion activity and concrete cracking. The difference between these states cannot be discerned from the GPR data.

NDT Corp. utilized a high frequency/ high resolution, ground coupled GPR system to collect the data on all the tested spans. The position of the GPR lines of coverage were discussed with CHA before data collection was performed. The conclusion was to examine the concrete deck health by focusing on the areas in between the girders. The girders were measured off the plans and the lines of coverage were adjusted to match the girder spacing.

An annotated GPR record from Span 5 EB is shown in Figure 9. A delamination was detected and is shown from station 19 to 26 as a horizontal band in the signal. The delamination's depth varied from 1 to 3 inches from the top surface of the concrete to the top reinforcing layer. This delamination is easily detected by hammer sounding. From station 26 to 30 is an example of an attenuated signal return from the reinforcing. Generally, this is indicative of an area of potential deterioration to the beginning of active deterioration. Hammer sounding will not detect this condition. The strong signal return from station 30 to 34 is indicative of an area with a low probability for deterioration.

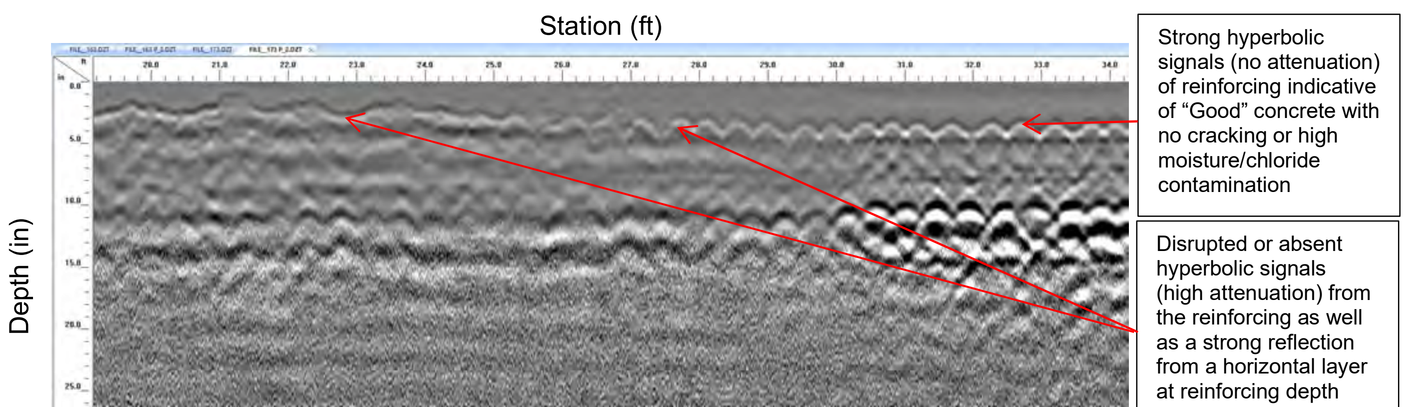

Figure 9: GPR record with delamination, Attenuated reinforcing, and reinforcing with no attenuation

Figure 10 through Figure 12 show typical GPR survey maps, while the maps for all the tested areas are presented in Appendix C. Ramp H was generally in good condition with majority of the tested area showing no attenuation (Figure 10). Span 4 condition was generally typical for the majority of the spans (Figure 11), while Span 12 represents the worse condition (Figure 12). Statistical analysis of the results is presented in Table 2. Overall, 52% of the tested area had no attenuation and is considered to be in good condition, while attenuation around the top reinforcement was observed in 48% of the tested area. Comparing the IE/PV data with the GPR data shows that the results obtained by these testing methods are very similar.

Figure 13 shows the IE/PV map overlayed on top of the GPR survey map for Span 4. Sound areas indicated by IE/PV testing generally corresponded to the areas of no attenuation in the GPR scans. This indicates that a large number of the areas where signal attenuation was observed in the GPR scans correspond to the areas of cracking and delaminations identified by the IE/PV testing. GPR signal attenuation in areas of sound concrete is most likely due to moisture or high chloride concentrations.

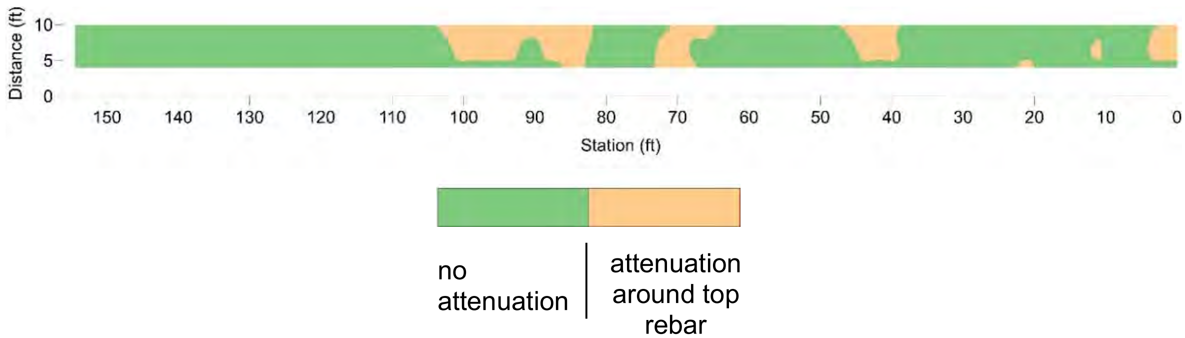

Figure 10: GPR Survey Map Ramp H

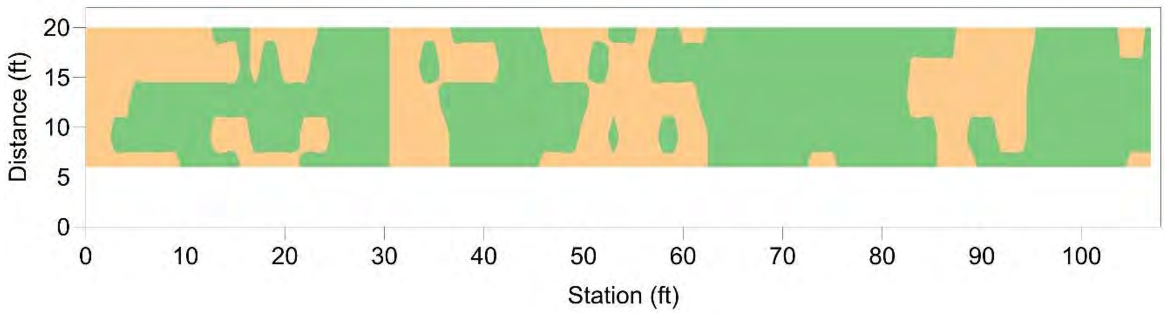

Figure 11: GPR Survey Map for Span 4 WB

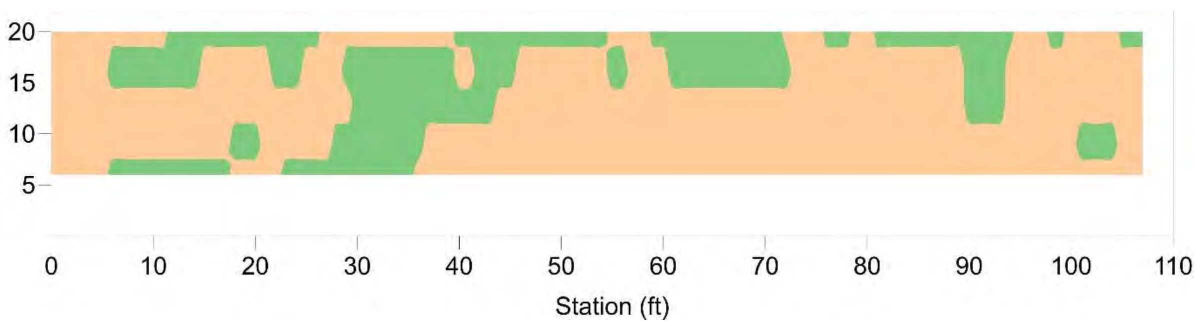

Figure 12: GPR Survey Map for Span 12 WB

Table 2: GPR Survey Summary

Span	Area with Attenuation around Top Reinforcement (%)	Area of No Attenuation (%)
1EB FL	45%	55%
2WB FL	55%	45%
3EB SL	54%	46%
4WB SL	37%	63%
5EB SL	62%	38%
6WB SL	45%	55%
7EB SL	15%	85%
8WB FL	55%	45%
9EB FL	33%	67%
10WB FL	67%	33%
11EB FL	54%	46%
12WB SL	71%	29%
13EB FL	50%	50%
14WB SL	46%	54%
15EB FL	34%	66%
Ramp H	20%	80%
Overall	48%	52%

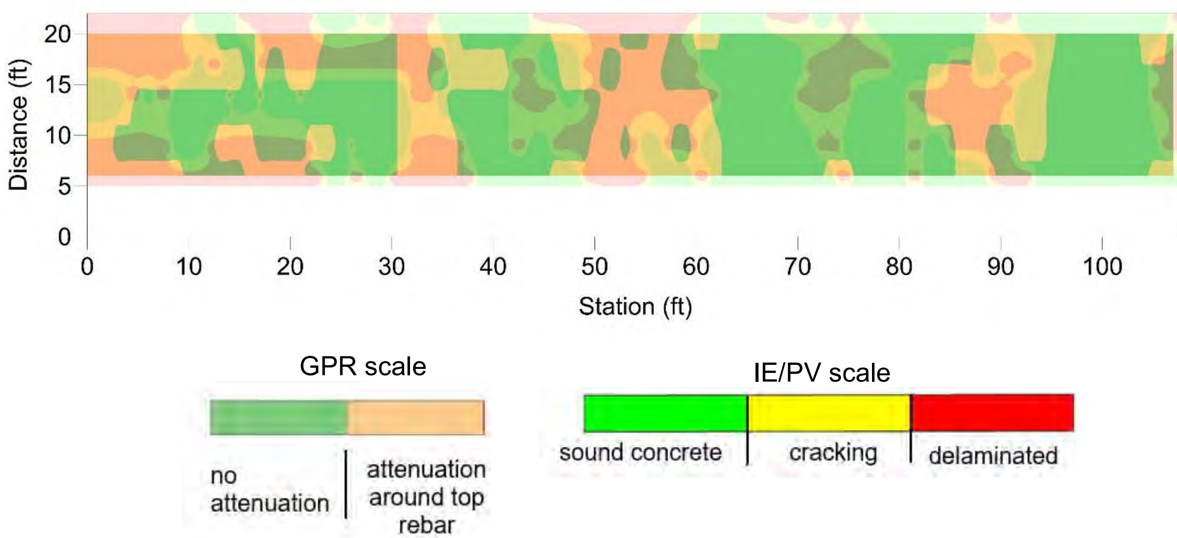

Figure 13: IE/PV Survey Map Overlayed on Top of the GPR Survey Map for Span 4 WB

Electrical Continuity of the Reinforcement

Electrical continuity of the reinforcing is necessary for possible future corrosion mitigation by cathodic protection and to conduct efficient corrosion potential measurements. In most cast-in-place reinforced concrete structures conventional reinforcement is electrically continuous due to the crossing of bars and use of uncoated tie wire. If the reinforcement is found to be electrically isolated, then continuity bonds are required for the implementation of cathodic protection (CP). Electrical continuity is verified by contacting various steel elements with the lead wires from a high impedance multi-meter using the DC millivolts and/or resistance settings. As per ACI 222R-01 Standard in Section 4.3.1.6a, if the potential difference between the reinforcing elements is less than one (1.0) mV, then the reinforcing steel is deemed electrically continuous.

Reinforcement in the deck was found to be electrically continuous. If a form of CP were to be applied to the deck, a more robust evaluation of electrical continuity should be conducted during the construction phase. However, it is expected that limited continuity corrections would be required.

Corrosion Potential Survey

To identify locations with a high probability of active corrosion, corrosion potential measurements were collected on a 2 ft x 2 ft grid in an area of sound concrete in each tested span.

Corrosion potential measurements were performed following ASTM C876 *Standard Test Method for Corrosion Potentials of Uncoated Reinforcing Steel in Concrete*. A copper/copper sulfate (CSE) reference electrode was used to collect corrosion potential measurements. The CSE reference electrode was placed on the concrete surface with a saturated sponge used to make an electrical couple with the concrete. The reference electrode was then connected to the negative terminal of a volt-meter. The positive terminal of the volt-meter was connected to the embedded reinforcement of the structure, and the potentials at various points along the walls were recorded. The magnitude and spatial variation of the measured potentials provides the probability for active corrosion at the test location.

A generally accepted interpretation of normalized CSE measurements is provided in the appendix of ASTM C876 (Table 3 and Figure 14). It is important to understand that the interpretation values provided in ASTM C876 are a general guideline based on values normalized to 72 degrees Fahrenheit, and are not absolute values. The threshold values can shift based on the concentration of moisture and oxygen in the concrete, as well as other environmental factors like temperature.

Table 3: ASTM C876 Interpretation of Data

Corrosion Potential	Probability of Active Corrosion
< -350 mV	90%
- 350 mV to -200 mV	Uncertain
> −200 mV	10%

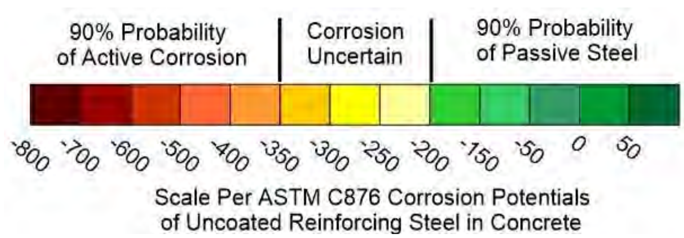

Figure 14: Corrosion Potential Survey Scale for Color Maps

Figure 15 through Figure 17 show typical corrosion potential survey maps. The maps for all the tested areas are included in Appendix D. Generally, reinforcement corrosion was wide-spread. Majority (81%) of the area was at 90% probability of active corrosion, 16% was in the uncertain range and 15% was at 90% probability of passive steel (Table 4).

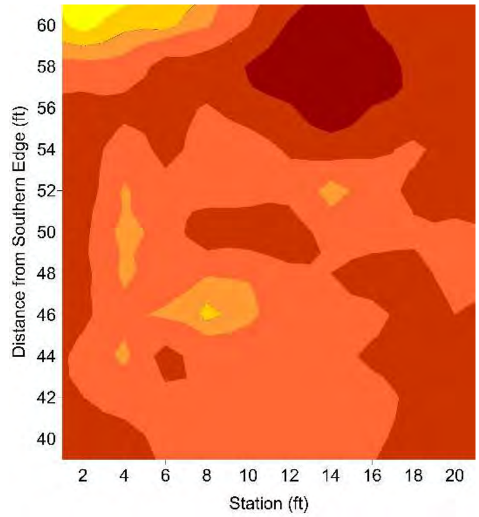

Figure 15: Corrosion Potential Survey of Span 3 EB

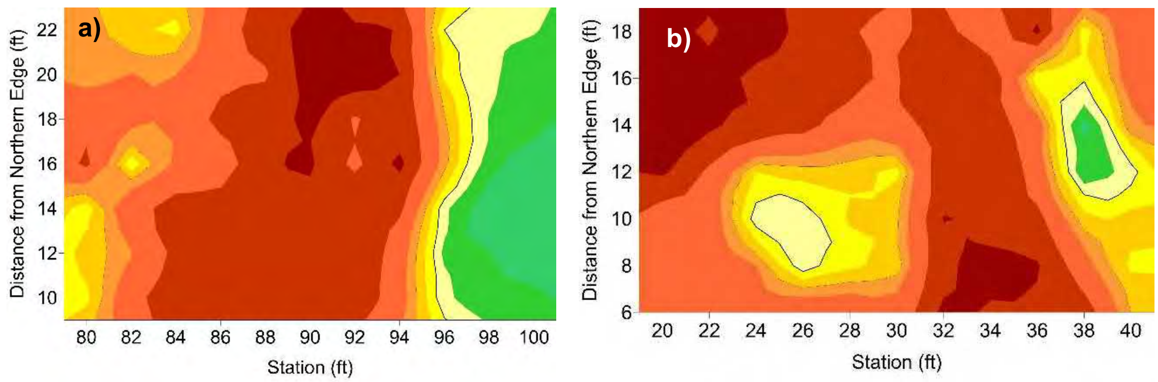

Figure 16: Corrosion Potential Survey of a) Area1 and b) Area 2 in Span 4 WB

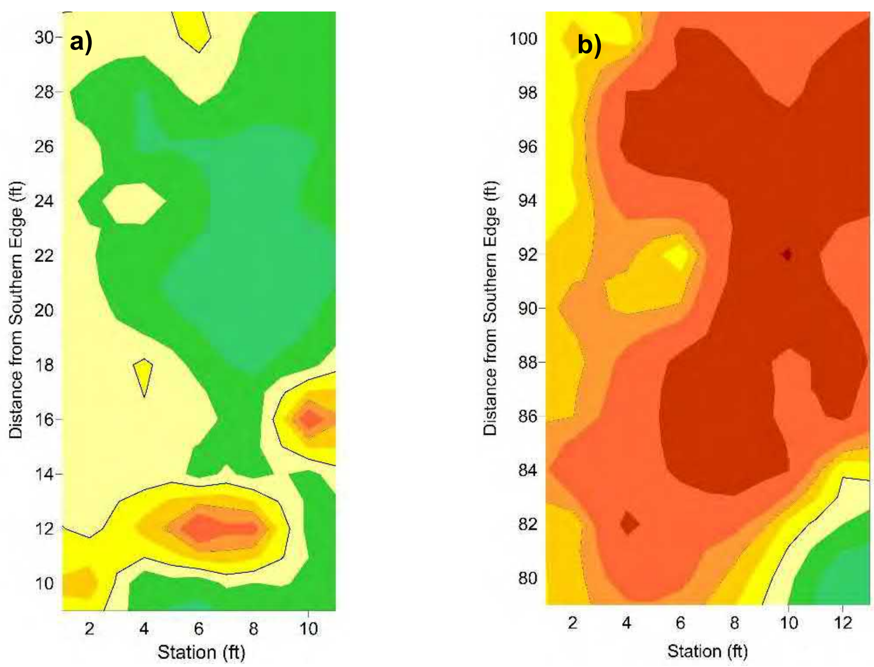

Figure 17: Corrosion Potential Survey of a) Area1 and b) Area 2 in Ramp H

Table 4: Corrosion Potential Survey Summary

Span	Area Indicating 90% Probability of Active Corrosion (%)	Area Indicating Uncertain Corrosion Activity (%)	Area Indicating 90% Probability of Passive Steel (%)
1EB HSL	95%	4%	1%
2WB HSL	100%	0%	0%
3EB SL	98%	2%	0%
4WB SL Area 1	69%	16%	15%
4WB SL Area 2	76%	23%	1%
4WB SL Overall	72%	19%	9%
5EB SL	99%	1%	0%
6WB SL	99%	1%	0%
7EB SL	100%	0%	0%
8WB HSL	88%	11%	1%
9EB HSL	15%	39%	46%
10WB HSL	100%	0%	0%
11EB HSL	36%	36%	27%
12WB SL	81%	19%	0%
13EB HSL	15%	45%	40%
14WB SL	100%	0%	0%
15EB HSL	1%	8%	91%
Ramp H Area 1	3%	43%	54%
Ramp H Area 2	78%	19%	3%
Ramp H Overall	44%	30%	26%
Overall	81%	16%	15%

Concrete Material Sampling

In addition to non-destructive methods, concrete material sampling was conducted to gain an understanding of the concrete composition and the amount of chloride ion contamination within the concrete matrix from atmospheric chloride exposure. Samples were collected in the form of 3-inch diameter cores from the deck. Table 5 provides a tabulated log of all the collected cores. A photo log of all the cores is included in Appendix E.

Table 5: Core Location Log

BIN	Lane	Core ID	Test
1065149	West EB Approach SL	1	Carbonation
1065149	Span 1 EB SL	2	Carbonation, chlorides
1065149	Span 3 EB SL	3	Carbonation
1065149	Span 5 EB SL	4	Carbonation
1065149	Span 7 EB SL	5	Carbonation, petrography
1065149	Span 9 EB HSL	6	Carbonation, compressive strength
1065149	Span 11 EB HSL	7	Carbonation
1065149	Span 13 EB HSL	8	Carbonation, chlorides
1065149	Span 15 EB HSL	9	Carbonation, petrography
1065149	East EB Approach	10	Carbonation, chlorides
1065149	Span 12 WB SL	11	Carbonation
1065149	Span 14 WB SL	12	Carbonation, compressive strength
106514A	Ramp H Approach	13	Carbonation, chlorides
106514A	Ramp H Approach	14	Carbonation, petrography
106514A	Ramp H	15	Carbonation, compressive strength
1065149	Span 6 WB SL	16	Carbonation
1065149	Span 4 WB SL	17	Carbonation, chlorides
1065149	West WB SL Approach	18	Carbonation, chlorides
1065149	Span 2 WB SL	19	Carbonation, petrography
1065149	East WB HSL Approach	20	Carbonation, compressive strength
1065149	Span 10 WB HSL	21	Carbonation, petrography
1065149	Span 8 WB HSL	22	Carbonation, chlorides

Carbonation Depth

The depth of carbonation into the concrete can indicate the risk for corrosion activity. Carbonation lowers the concrete's pH as carbon dioxide diffuses into moist concrete. If the pH of the concrete surrounding the reinforcing steel is lowered below pH 11, depassivation of the reinforcing begins and general corrosion initiates. Carbonation can cause corrosion in concrete that has not been contaminated with chlorides and can also propagate through crack surfaces. In chloride-contaminated concrete, carbonation can work in tandem with chlorides to initiate corrosion much more quickly.

To identify the depth of the carbonation front in concrete, a pH indicator solution is sprayed onto freshly extracted and cleaned concrete cores. The indicator solution changes to a pink/purple color at pH greater than 9.5. If the solution is clear, that is an indication of carbonated concrete; if the solution turns purple or pink on the concrete then that is an indication of uncarbonated or alkaline concrete.

Cores were tested for carbonation in the field immediately after coring. Essentially no carbonation was measured in the cores. Since the depth of carbonation was less than 1/8 in, carbonation-induced corrosion is not a contributing factor to the concrete deterioration observed in the deck.

Concrete Chloride Sampling

Reinforcing steel in concrete is protected from corrosion by the high alkalinity of the concrete pore solution, typically greater than a pH of 12. The high pH of the pore solution causes formation of a passivating film on the surface of rebar, effectively sealing it and preventing corrosion. Corrosion of reinforced concrete exposed to chloride ions initiates when sufficient chloride contamination reaches the reinforcing to break down the passivating film. The generally accepted chloride threshold for the initiation of corrosion at the depth of steel in reinforced concrete is ~350 ppm, or 0.4% by mass of cementitious materials. Concrete can also contain background chlorides, which were either admixed into fresh concrete or are naturally present in cement products or aggregates. Admixed chlorides could be added to the concrete mix through the use of chloride-containing chemical admixtures or the use of seawater instead of potable water. Admixed chlorides and chloride ions that diffuse into the concrete from the environment are referred to as "free" chlorides and are responsible for chloride-induced corrosion in reinforced concrete. Chlorides present in the aggregate are chemically bound and are not able to initiate corrosion. The chloride threshold is critical in determining the initiation time for the service life model. In the literature, threshold concentrations for chloride in concrete can vary significantly and depend on a number of factors. ACI 222R-19 indicates that for acid-soluble chloride testing, the generally accepted chloride threshold in the United States is between 1.0 and 1.5 lbs of chloride per cubic yard of concrete (263 to 395 ppm assuming a concrete density of 3,800 lbs/yd^3).

For the service life modeling, VCS typically implements a chloride threshold of 350 ppm with a standard variation of 50 ppm. It is important to consider the variation of the threshold as the chloride threshold is not a single value. Due to many influencing factors, corrosion of steel in concrete can initiate at a range of chloride concentrations. As a result, it is important to take into consideration this variation. There are many environmental and concrete material conditions that can cause the corrosion to initiate at a lower or higher threshold. For example, if the moisture content is high in an area, then corrosion may initiate at a lower chloride concentration. If the concrete is drier in an area, it may take more chloride to cause corrosion. Also, if carbonation penetrates to the reinforcing depth, no chloride is needed to initiate corrosion.

Figure 18 shows the chloride profiles for all the collected samples. The average reinforcement cover-depth and the average plus/minus one standard deviation are indicated in the plot by vertical green lines, and the chloride threshold value of 350 ppm is plotted as a horizontal red line.

Chloride concentration at rebar depth was above the corrosion initiation threshold of 350 ppm for all the samples, except for cores 8 and 17 where the chloride concentration was at the lower bound of the threshold (300 ppm). This indicates high risk for chloride-induced corrosion of the top reinforcement mat throughout the deck.

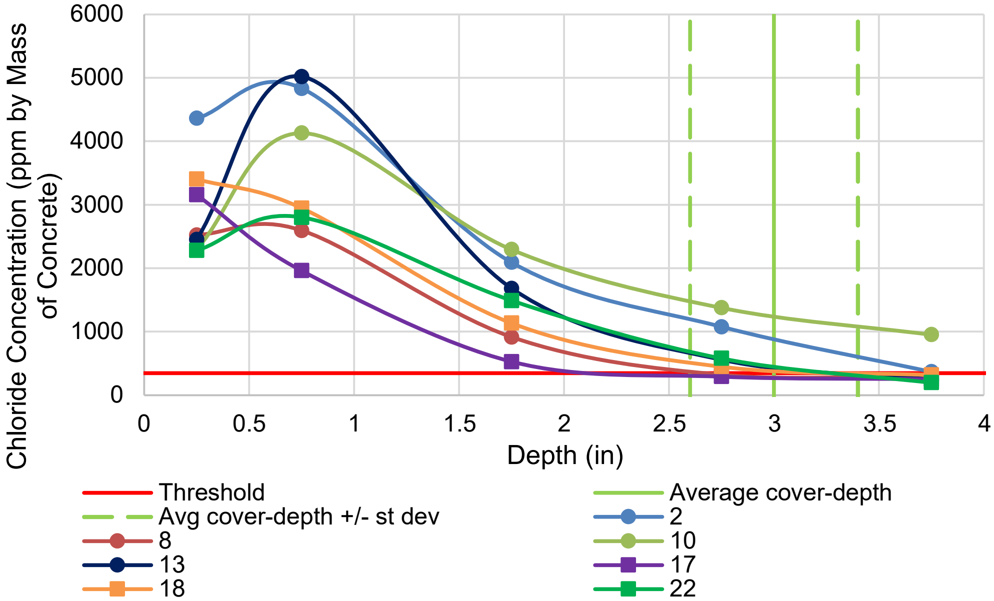

Figure 18: Chloride Concentration Profiles from the Extracted Cores

Service Life Modeling

Rebar corrosion in reinforced concrete is typically divided into two stages: initiation and propagation. The initiation period is the time it takes for the chloride ions to diffuse from the concrete surface to the rebar and reach a threshold concentration (350 ppm) above which rebar will start to corrode. Propagation time is the time from the corrosion initiation to when enough corrosion product has formed at the steel surface to create a concrete crack or delamination.

Most practitioners will assume between 3 to 7 years for the propagation time (NCHRP 558) (*Life-365 Service Life Prediction Model and Computer Program for Predicting the Service Life and Life-Cycle Cost of Reinforced Concrete Exposed to Chlorides Version 2.2.1 User's Manual*, the Life-365 Consortium III, January 2014). Literature has tried to calculate the propagation time using variables such as the cover-depth, concrete tensile strength, diameter of the reinforcement bar, corrosion rate, and corrosion product volume expansion. These calculations determine the amount of corrosion product required to create enough internal stress in the concrete to create a crack or delamination.

During the propagation phase corrosion products cause surface defects like cracking, delamination and spalling that can be visually detected. In this stage the deterioration rate of the steel accelerates, and substantial section-loss of the steel starts to occur. Since the concrete cover depth and contamination are not uniform, corrosion initiation, propagation, and surface deterioration occur simultaneously in different locations on the structure or element.

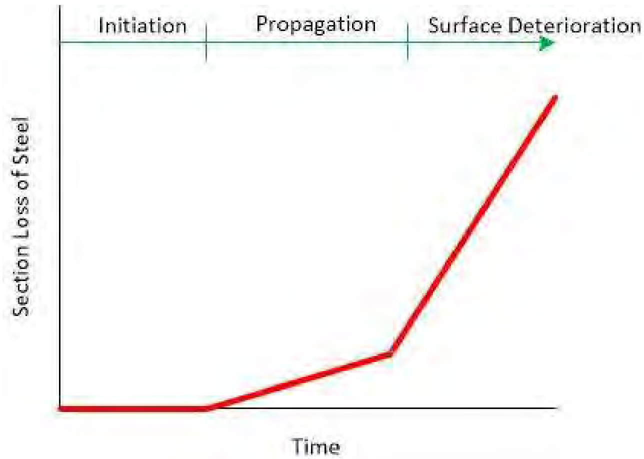

Figure 19: Basis of Service Life Model

The initiation phase is primarily modeled by the transport of chloride into concrete using Fick's Laws of Diffusion, or in a similar manner exponentially for carbonation. Fick's Laws are based on kinetic theory and the random motion of molecules. It should be noted that Fick's Laws of Diffusion are only applicable to uncracked concrete. Any location with a crack or near another type of transport anomaly is going to have a much higher rate of chloride exposure. Smeared-crack techniques and probabilistic approaches are used to adjust the calculations to explain real-world observations.

Fick's First Law of Diffusion indicates that the rate at which chloride transports through concrete is proportional to the concentration per unit distance and a constant that is based on the concrete properties. Fick's Second Law of Diffusion provides a time dependency to the model. Using the Fick's Laws, an equation for the chloride concentration with depth of a permeable solid element can be developed (Equation 2).

Using Equation 2 the time to reach the chloride threshold at the depth of steel can be determined by making $C_{(x,t)}$ equal to the chloride threshold, *x* equal to the cover-depth and then solving for *t*. As a result, Equation 2 is rearranged into the form presented in Equation 3, which is used to determine the duration of the initiation phase.

$$C_{(x,t)} = C_o\left(1 - erf\,\frac{x}{2\sqrt{D_c t}}\right) \qquad \text{Equation 2}$$

erf	Mathematical error function
$C_{(x,t)}$	Chloride concentration at depth x after exposure time t
C_0	Constant chloride concentration at the surface
D_c	Diffusion coefficient
t	Time
x	Depth from exposure surface

$$t = \frac{1}{4D_c}\left(\frac{X_{cover-dept}}{inverse\ erf\left(1 - \frac{C_{threshold)} + C_O}{C_O}\right)}\right)^2 \qquad \text{Equation 3}$$

ACI Life 365 and NCHRP 558 *Manual on Service Life of Corrosion-Damaged Reinforced Concrete Bridge Superstructure Elements* use chloride profiles of cores collected in the field to determine C_0 and D_c for modeling the initiation phase (Equation 2). These variables are determined by conducting a least square error regression analysis of the chloride profile using Equation 2.

In order to understand the risk of chloride-induced corrosion, the first step was to use the chloride test data to determine C_0 and D_c. The statistical analysis of the calculated C_0 and D_c values is presented in Table 6.

Table 6: Surface Chloride Concentration and Diffusion Coefficient Statistics

Element	Variable	Average	Standard Deviation	Minimum	Maximum
Deck	C_0 (ppm)	4,801	1,887	2,972	8,470
	D_c (in^2/yr)	0.036	0.018	0.014	0.061

The most important factor in the service life of reinforced concrete structures during the initiation phase is the depth of concrete cover. Cover-depth has a significant impact on the time it takes for chlorides to diffuse to the steel reinforcement. The length of the initiation period from the time of construction (1970-1972) was calculated for diffusion coefficients D_c ranging from the average minus standard deviation to average plus standard deviation (0.018 to 0.055 in^2/year) and a cover-depth variation from 2.6 to 6.0 in. This cover-depth range encompasses the average cover-depth minus one standard deviation for the top reinforcement mat and the expected depth of the bottom reinforcement mat. The analysis was carried out using the average chloride surface concentration C_0.

As can be seen in Figure 20, reinforcement with cover-depths of up to 3 inches has already reached the end of the initiation period for the average value of D_c. At high values of D_c, reinforcement with cover-depths up to 4 inches has also reached the end of the initiation period. It should be noted that the model in Figure 20 only applies to areas of sound concrete. Sub-vertical cracks in the top of the deck would provide a direct path for chlorides into the concrete cross-section, which will significantly reduce the expected service life of the bottom reinforcement mat.

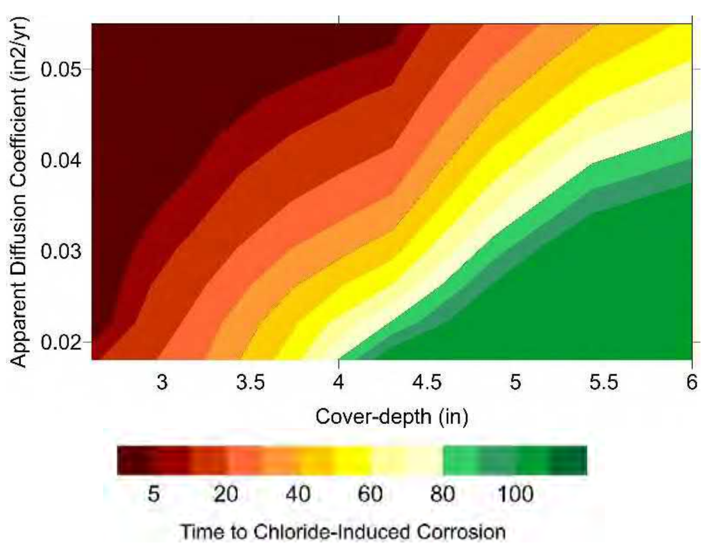

Figure 20: Projected Time to the End of the Initiation Period for the Deck from the Date of Inspection (Year 2021)

Compressive Strength

Cores for compressive strength measurements were sampled and tested in accordance with ASTM C42 *Obtaining and Testing Drilled Cores and Sawed Beams of Concrete*. The results of compressive strength testing for individual cores are listed in Table 7. The average compressive strength of the cores was 3,780 psi, which is below the 4,000-5,000 psi typical of cast-in-place concrete construction.

Table 7: Compressive Strength of Concrete Cores

Core ID	L/D	L/D Factor	Max Load (lbf)	Corrected Compressive Strength (psi)
6	2.0	1.00	20,887	3,460
12	1.7	0.98	25,818	4,200
15	1.6	0.97	22,462	3,610
20	2.1	1.00	23,147	3,840
		Average		**3,780**
		Standard deviation		**318**

Petrographic Analysis

A petrographic analysis, in accordance with ASTM C856 *Standard Practice for Petrographic Examination of Hardened Concrete*, was conducted on cores 5, 9, 14, 19 and 21. The petrographic analysis can identify if there are any physical deterioration processes such as freeze-thaw, or chemical deterioration processes such as alkali-silica reaction (ASR) or sulfate attack occurring in the concrete. Petrographic analysis also defines the general properties and volumetric proportions of the concrete mixture used in the original construction.

The following provides an overview of the important findings from the petrographic analysis. The complete petrographic report is provided in Appendix F.

- General Appearance of Cores
    - The concrete in all 5 cores contained similar components
    - All cores exhibited worn and deteriorated top surfaces with exposed aggregate
- Concrete Paste
    - The paste consisted of hydrated Portland cement with no supplementary cementitious materials
    - The water-to-cement (w/c) ratio was estimated to be 0.40±0.05 in all the cores
- Voids
    - The concrete was air-entrained, and the total air content was visually estimated to be 5-7%
    - The concrete was well-consolidated with no significant entrapped voids
- Aggregates
    - The coarse aggregate was a crushed limestone with minor to trace amounts of quartz, chert and pyrite.
        - Quartz and chert are potentially susceptible to ASR
            - Evidence of ASR was observed in cores 14 and 21
        - Nominal maximum size of 3/4 in with somewhat uneven gradation

    - Fine aggregate was siliceous natural sand that consists primarily of quartz with minor amounts of quartzite, feldspar, granitic rocks, mica and chert.
        - Quartz, quartzite, granitic rocks and chert are potentially susceptible to ASR
            - No ASR associated with fine aggregate was observed in any of the cores
- Secondary Deposits
    - The concrete contained secondary deposits of calcium carbonate (due to paste carbonation) in the top 40 mil of the cores and along sub-vertical cracks and microcracks up to 240 mil
    - Ettringite was occasionally observed lining the voids near the top of the cores
        - This indicates that concrete has experienced periods of prolonged exposure to moisture
    - Cores 14 and 21 showed the presence of ASR gel in voids and rare microcracks surrounding reactive particles
        - The severity of ASR was rated as minor and the extent of ASR was limited
        - No evidence of ASR was observed in cores 5, 9 or 19
- Cracking
    - All 5 cores had shallow sub-vertical to diagonal microcracks that are consistent with wear and salt scaling
    - Core 14 had 2 sub-vertical cracks that extended from the top 0.5 in and 2 in below the surface
    - Core 21 had sub-vertical microcracks that extended to 3/8 in below the top surface
        - These cracks and microcracks are characteristic of drying shrinkage

Conclusions

Based on the results of the field investigation and laboratory analysis, the following conclusions can be made:

1. Wide-spread concrete deterioration was observed in the top of the deck in both BIN 1065149 and BIN 106514A.
    a. Impact echo/pulse velocity testing indicated that 41% of the tested area is delaminated, 19% of the area shows the presence of cracking and only 40% is sound.
    b. GPR scans showed attenuation of the GPR signal around the top reinforcement mat in 47% of the tested area, which is due to the presence of concrete cracking, delaminations, high moisture or chloride contamination around the top reinforcement. 1% of the tested area showed attenuation around the bottom reinforcement mat, and 52% of the area had no attenuation. Comparing these results to the impact echo/pulse velocity testing, it can be concluded that most of the attenuation around the top reinforcement can be attributed to the presence of cracking and delaminations.

2. It is concluded that the concrete deterioration observed in the top of the deck is due to active corrosion of the top reinforcement mat caused by penetration of chloride ions to the rebar depth.
    a. 81% of the tested area was at 90% probability of active corrosion.
    b. Chloride concentration at rebar depth was above the corrosion initiation threshold for 5 out 7 tested samples, while for 2 of the samples it was at the lower bound of the threshold.
    c. Scaling caused by de-icing salts was observed in the top of all the cores examined during petrographic analysis.
3. Although petrographic examination indicated the presence of alkali-silica reaction in 2 out of 5 tested cores, its severity was rated as minor and its extend was limited. Therefore, it was concluded that alkali-silica reaction was not a contributing factor to the deck deterioration.
4. Carbonation is not a contributing factor to rebar corrosion observed in the top of the deck for both BIN 1065149 and BIN 106514A.

Recommendations

After reviewing the data collected regarding the condition of the deck in BIN 1065149 and BIN 106514A, VCS has developed several options to consider for its rehabilitation. Each of these options has its own advantages and disadvantages based on initial cost, long-term maintenance cost, impact on service life, and constructability. These are presented as preliminary options that need further development to establish accurate quantities and rehabilitation pricing. This would need to be done prior to final selection of a repair option.

Based on the current condition of the deck, basic repairs will not provide an appreciable service life extension to the deck and are not recommended. It would be possible to extend the service life of the deck by performing a deck overlay with global cathodic protection if the deck were not in an advanced state of deterioration; however per the in-depth inspection report, the Ramp H deck exhibits multiple areas of dampness and map cracking. Therefore this option is not feasible.

Option 1: Basic Repairs

The Basic Repairs option is that only currently delaminated areas are repaired and no corrosion mitigation is conducted. That would mean that the reinforcing steel would continue to corrode due to the high concentration of chlorides and concrete would continue to delaminate. This will lead to more and more spalls developing each year. Corrosion deterioration is exponential in growth so each year more and more damage will occur until the structure deteriorates to a point where serviceability becomes a concern. While this is the cheapest option in the short term, in the future when repairs are required to address serviceability concerns, the cost of those repairs will be much greater. Repairs during a state of severe deterioration are always significantly more expensive than conducting smaller-scale repairs earlier in the structure’s life so that it does not develop severe deterioration.

Delamination Repair
For the Basic Repair option, the currently spalled and delaminated areas will need to be repaired. For patch repair of the concrete, VCS recommends that the project utilize basic concrete repair procedures as developed by the International Concrete Repair Institute (ICRI), in particular *ICRI Technical Guideline No. 310.1R - Guideline for Surface Preparation for the Repair of Deteriorated Concrete Resulting from Reinforcing Steel Corrosion.* This

guideline covers recommended procedures for concrete removal, patch configuration and steel and concrete surface preparation.

When the localized concrete repairs are completed, chloride-contaminated concrete is left in place adjacent to the repair. The reinforcing steel crosses the interface between the original contaminated concrete and the completed concrete repairs which are chloride-free and alkaline. This incompatibility can accelerate corrosion around the repairs in the adjacent chloride-contaminated concrete; this phenomenon is referred to as the ring anode affect (Figure 21). A common method to mitigate the effects of ring anode corrosion is the use of embedded galvanic anodes within the repair area. Embedded galvanic anodes consist of zinc as a sacrificial metal encased in an activating mortar. When connected to the reinforcing steel within the completed concrete repairs, a small level of protective current is generated to mitigate the formation of new corrosion sites in the surrounding concrete. Embedded galvanic anodes are available in a range of sizes and shapes and are spaced along the steel surface area based on the risk for corrosion. A good ACI reference for the use of embedded galvanic anodes is *Repair Application Procedure Bulletin #8 – Installation of Embedded Galvanic Anodes*. For this application VCS recommends Type 1A anodes (standard concrete repairs, alkali activated).

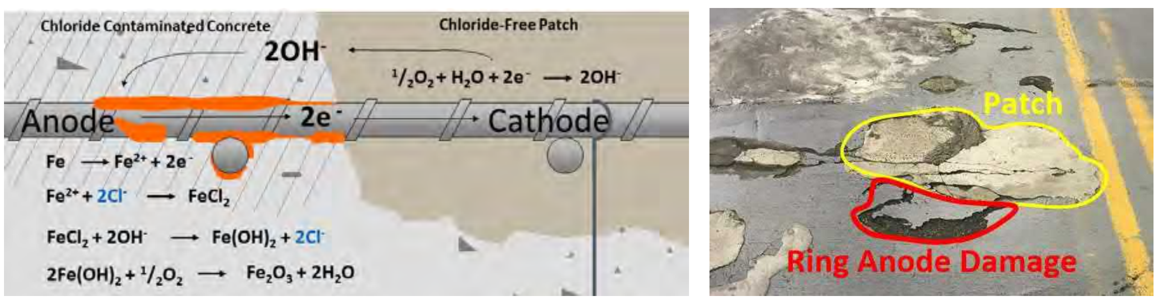

Figure 21: Ring Anode Effect

Contractor Selection and Inspection
In addition to a well-developed technical specification, contracting and inspection practices should be incorporated in the repair strategy. For example, utilizing prequalified specialty concrete repair contractors that have successfully completed similar types of work has been a successful approach. For improved inspection, utilizing an ICRI Certified Concrete Surface Repair Technician (CSRT), which is a competency-based program, should be considered.

Option 2: Deck Overlay

The feasibility of the deck overlay rehabilitation option depends on the condition of the bottom of the deck, which was not in the scope of this non-destructive evaluation. If the bottom of the deck is in relatively good condition, with minor spalls and delaminaitons, then the deck can be rehabilitated with a deck overlay. However, if concrete deterioration is wide-spread in the deck underside, a complete deck replacement would be required.

Due to the extensive delaminations in the top of the deck, the top of the deck can be removed and replaced with new concrete. This can be accomplished by hydrodemolition, which would remove approximately 4 in of concrete to below the top rebar. This will also remove concrete with the highest chloride contamination. Currently there are high chloride concentrations in the deck concrete, especially near the surface. If the top 3-4 in of the concrete are removed this will reduce the driving chloride concentration, thus slowing the rate of chloride diffusion. In addition, a latex-modified concrete overlay will provide a high-quality barrier to future chloride exposure. High quality overlays are used frequently in the surrounding region and it could provide a 15-20 year service life extension to the deck.

Concrete Patch Repairs

During the hydrodemolition operation it is expected that some full depth delaminations will be encountered due to corrosion of the bottom reinforcing steel. Concrete in all the spalled and delaminated areas (if any are present) should be removed following the delamination repair procedures described in Option 1, including the installation of Type 1A anodes within the repair area.

In areas of the deck underside that are exhibiting cracking and efflorescence that are sound and do not require a full-depth repair, it is recommended to install Type 2 distributed galvanic anodes to prevent concrete deterioration from corrosion due to chloride ions that have penetrated through the cracks to the bottom reinforcement mat. These anodes can be placed on top of the remaining original concrete, below the top reinforcement mat after the hydrodemolition has been completed and before the overlay is placed. Once the anodes are installed, a wire is used to connect them to the bottom reinforcement. Since the overlay concrete is expected to have high resistivity, a low-resistivity mortar would need to be placed around the anodes to provide an electrolytic bridge to the original concrete. Galvanic anodes can be designed for a 20-25 year life span, so a 30-year service life extension can be achieved when galvanic anode installation is combined with the application of a waterproofing coating. It is important to note that regular coating maintenance will help insure continued performance of this repair option to 30 years and beyond.

It is also recommended to seal all the cracks in order to prevent chloride and carbonation ingress into the deck cross-section.

Contractor Selection and Inspection

In addition to a well-developed technical specification, contracting and inspection practices should be incorporated in the repair strategy. For example, utilizing prequalified specialty concrete repair contractors that have successfully completed similar types of work has been a successful approach. For improved inspection, utilizing an ICRI Certified Concrete Surface Repair Technician (CSRT), which is a competency-based program, should be considered.

Option 3: Removal and Replacement of the Deck

Another option is to complete remove and replace the deck. This option is likely the highest initial cost option but offers the opportunity to incorporate modern corrosion resistant materials that can reduce future maintenance costs and provide long service life. If this option is selected, no cathodic protection (CP) is required.

Thank you for the opportunity to work with you on this project and if you have any questions, please don’t hesitate to contact me directly.

Sincerely,

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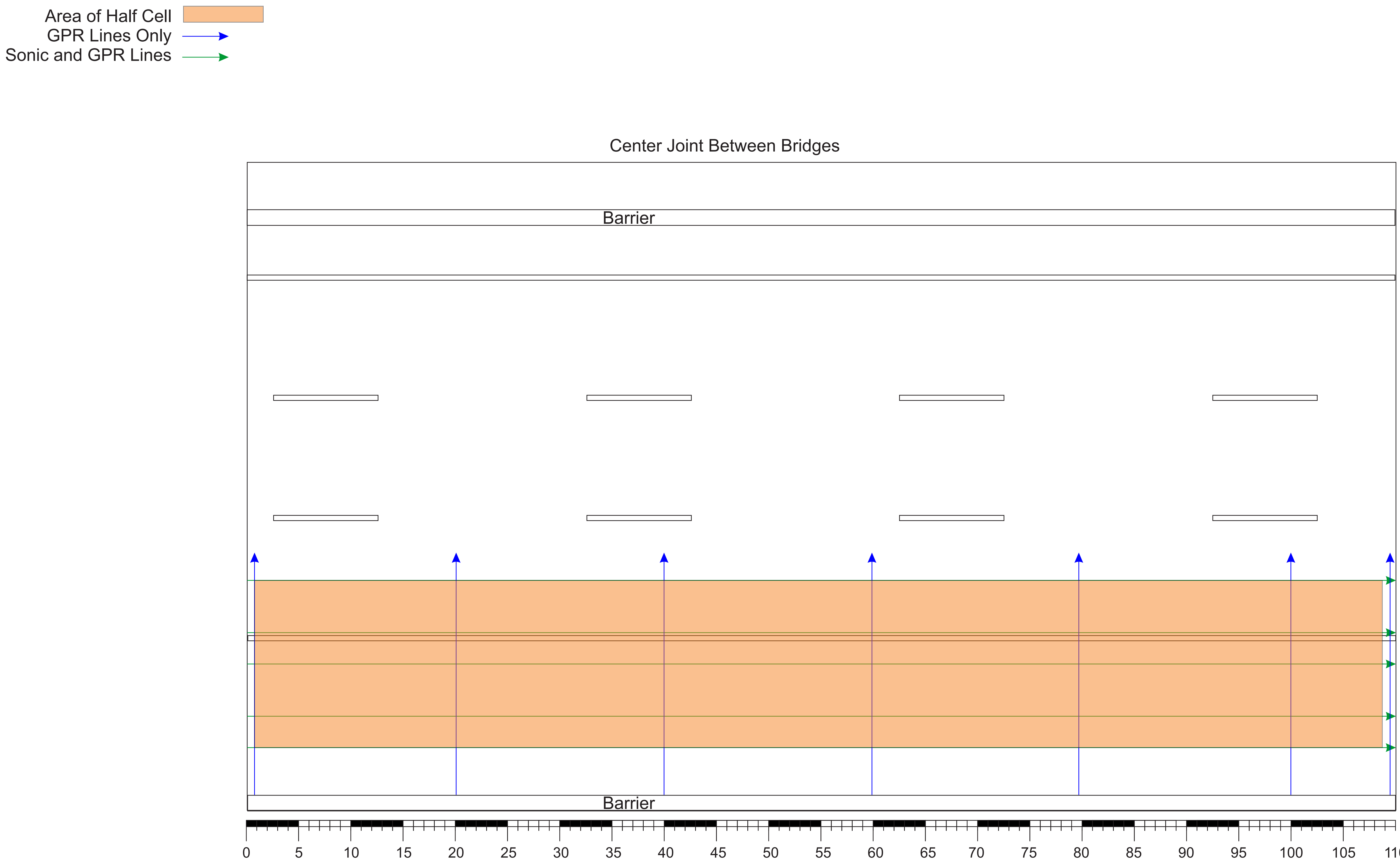
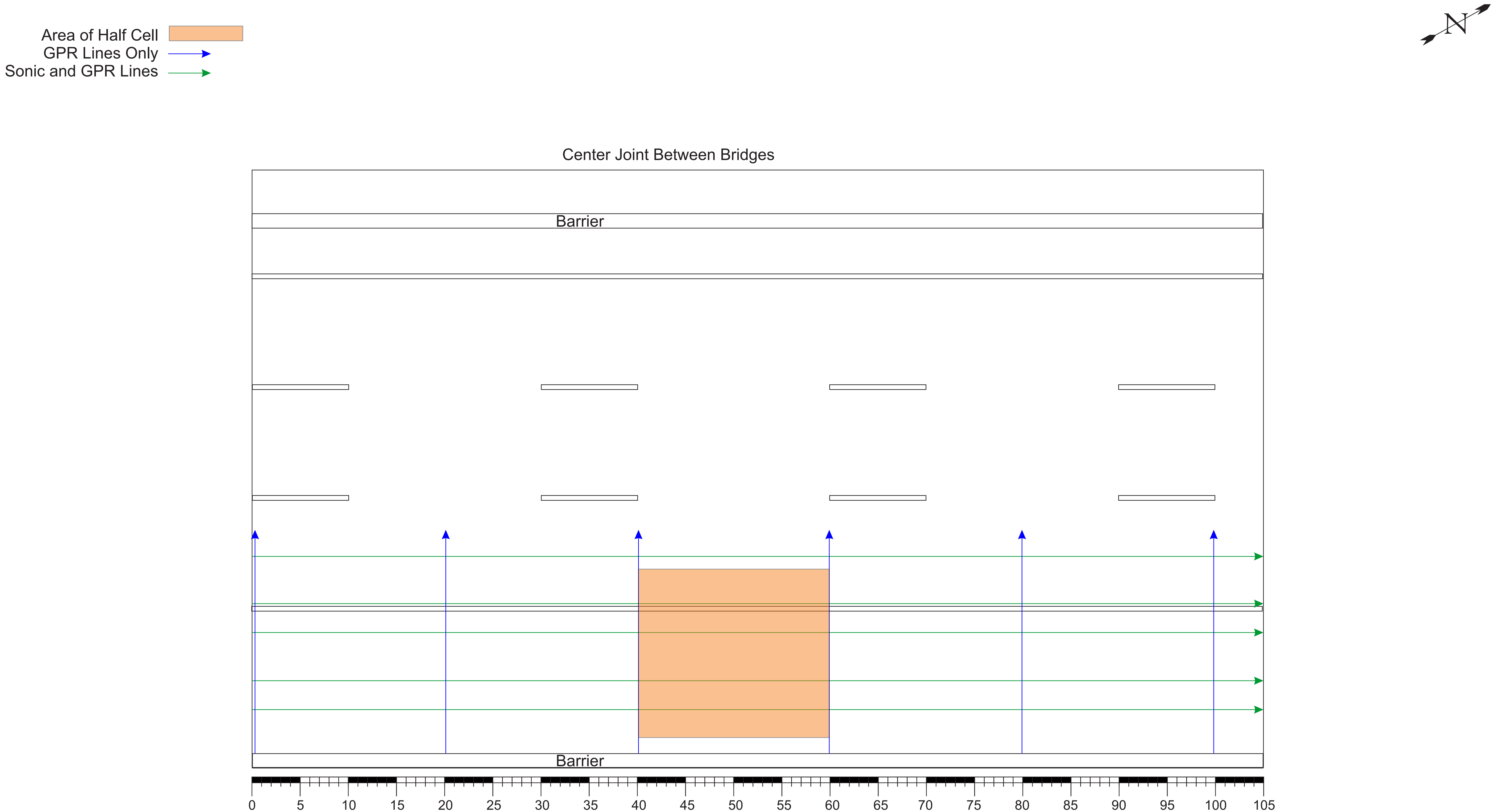
Engineer III
Vector Corrosion Services
natallias@VCServices.com
Office (813) 501-0050
Mobile (813) 460-1346

Appendix A
Testing Locations Map



Testing Coverage BIN 1065149 Eastbound Span 1



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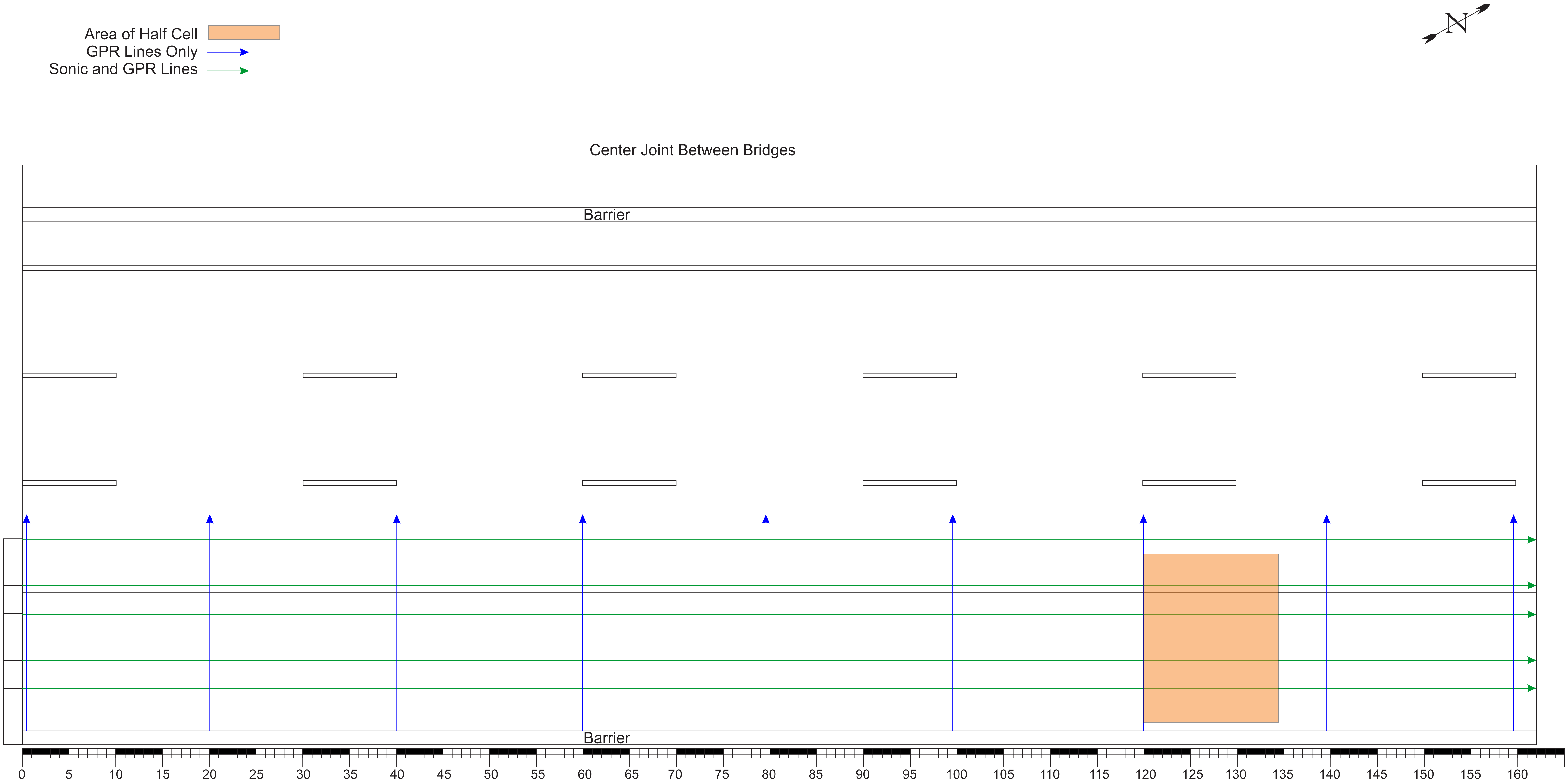

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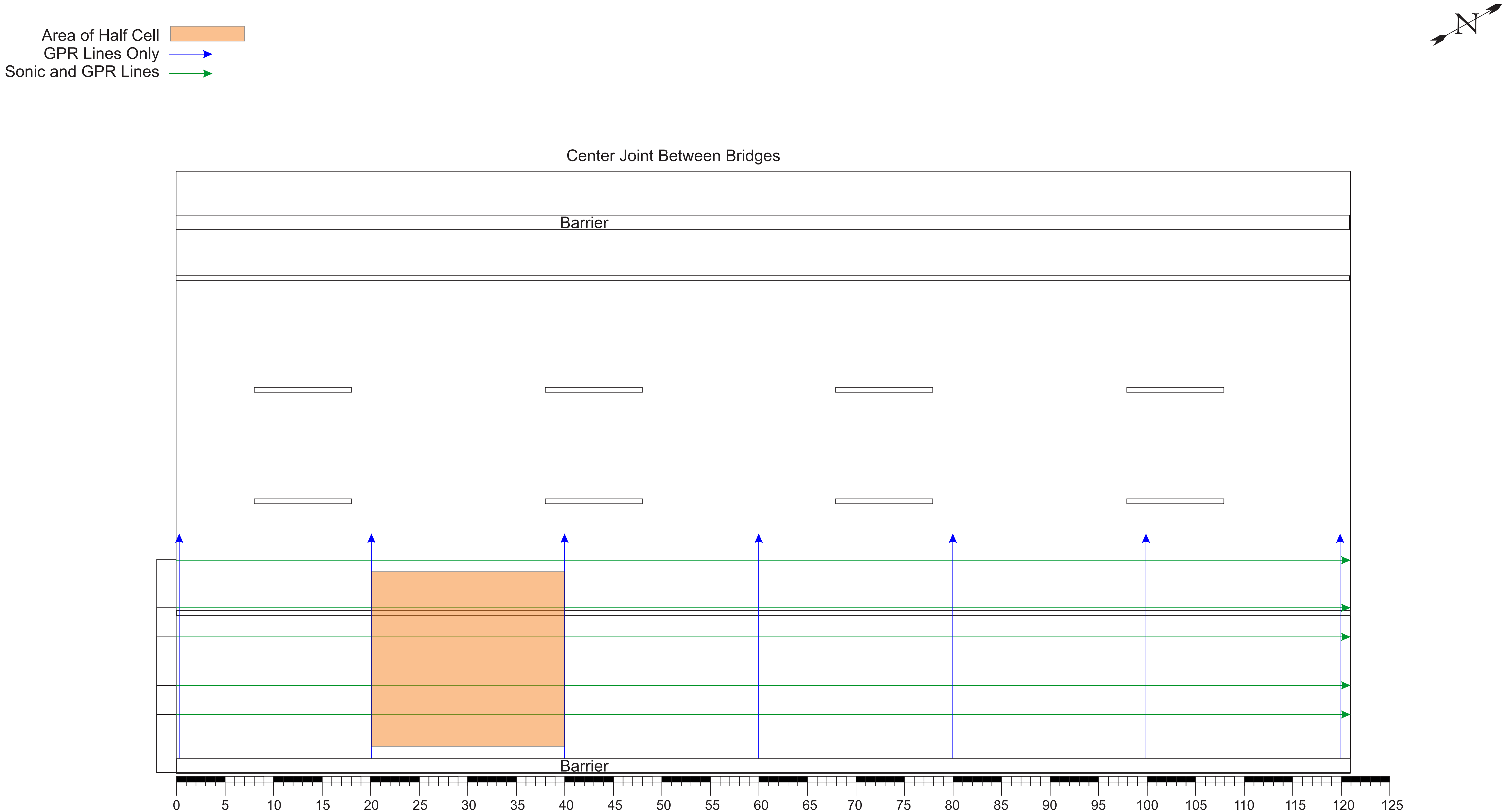

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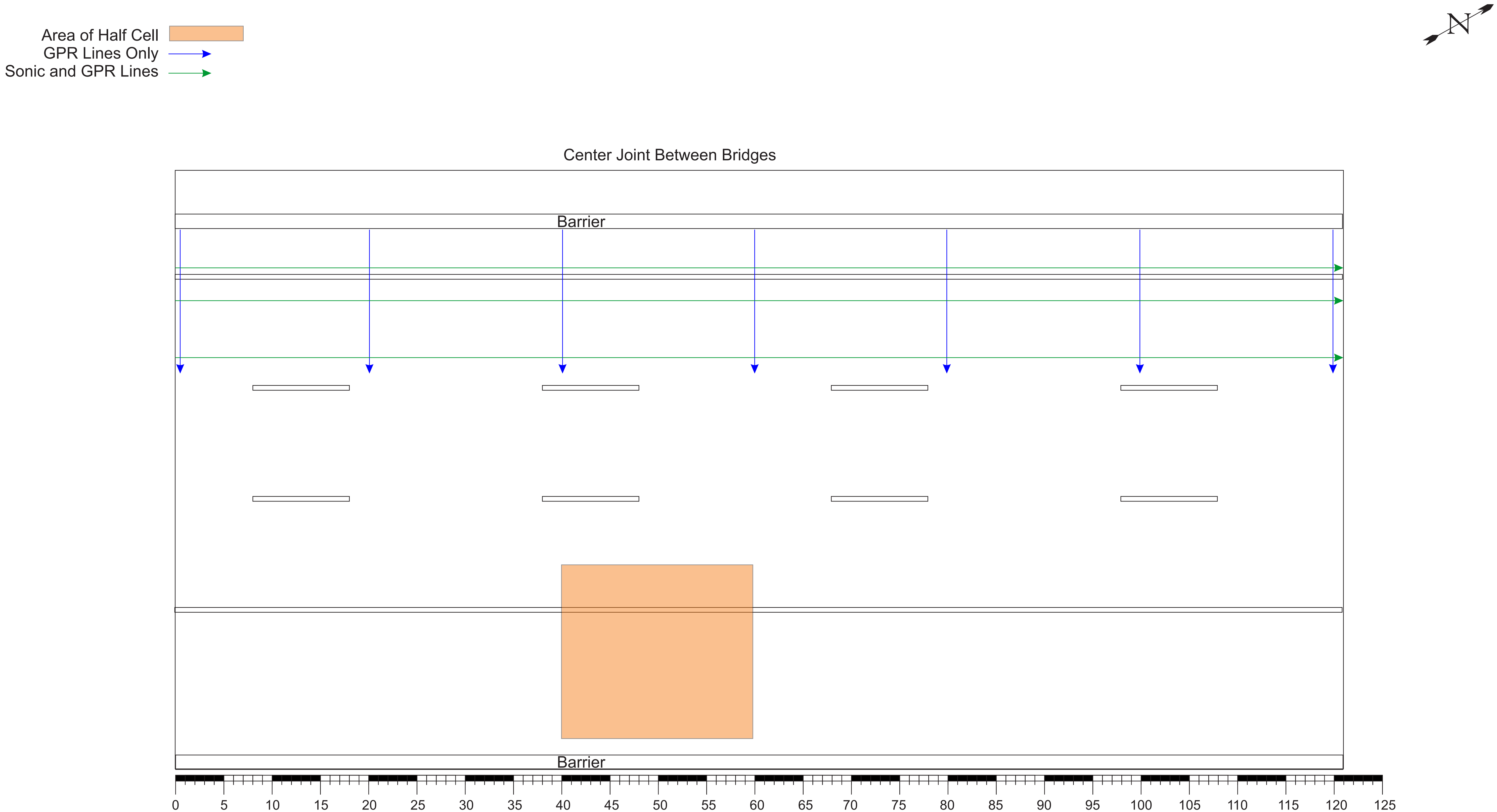

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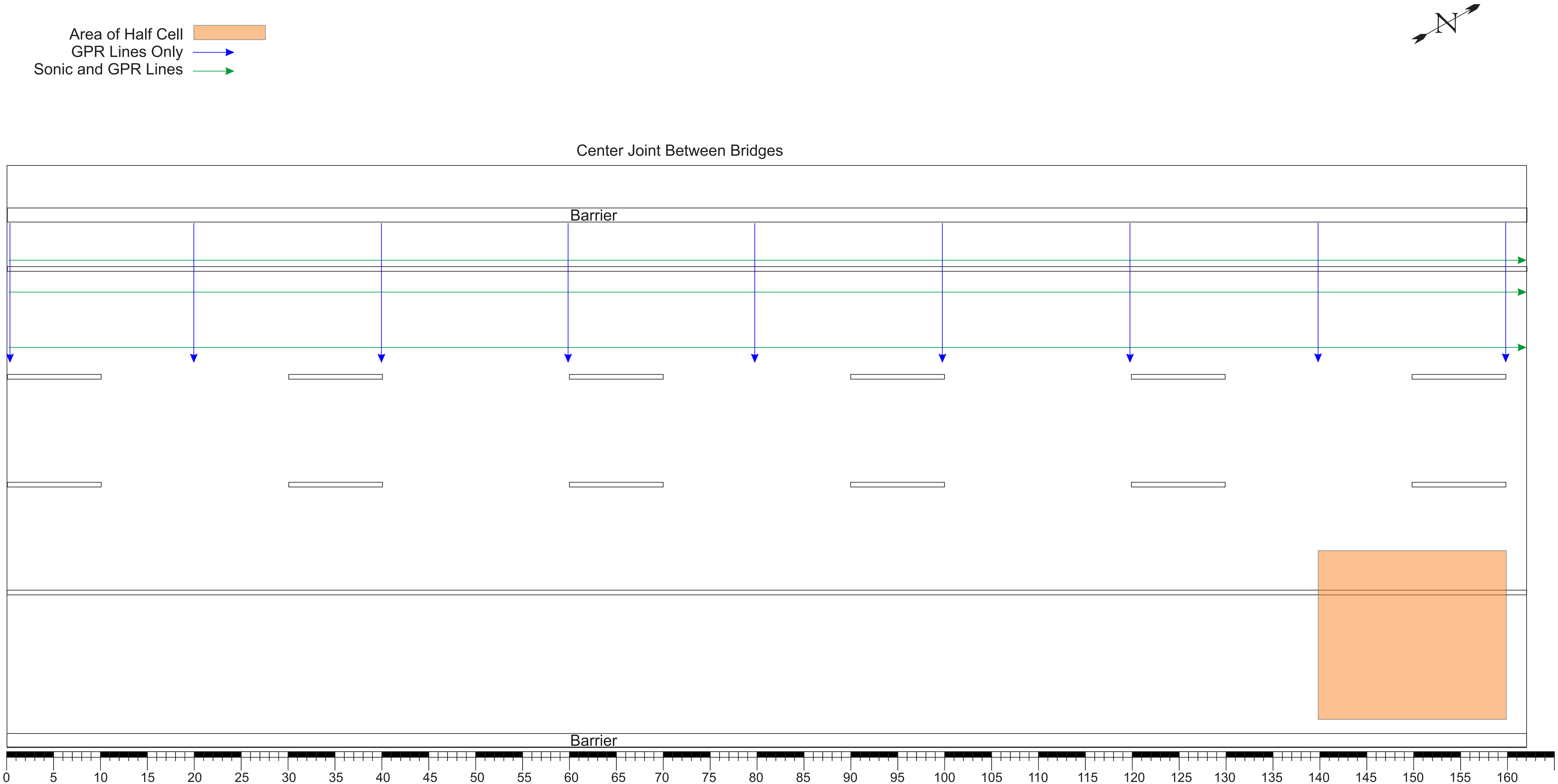

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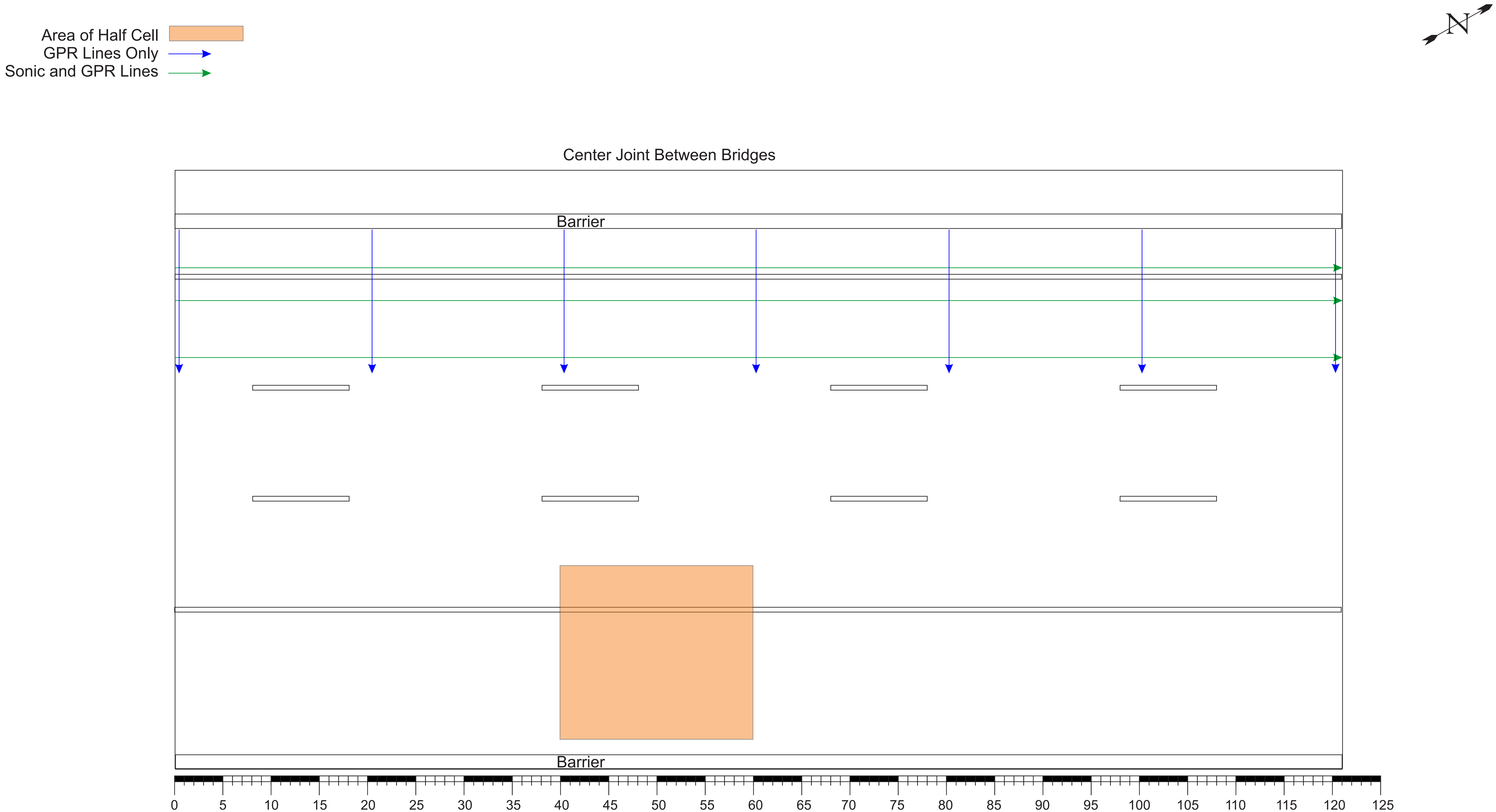

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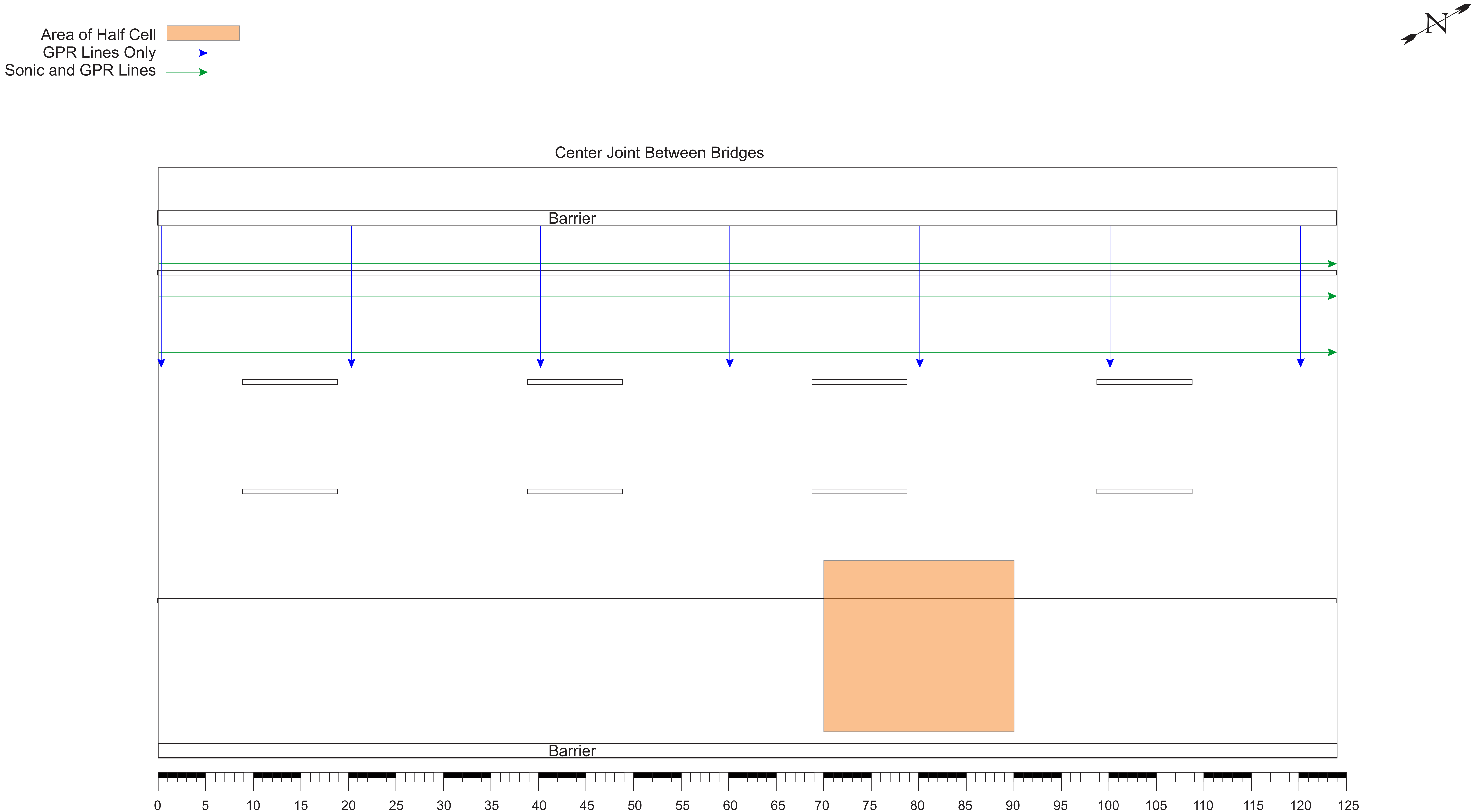

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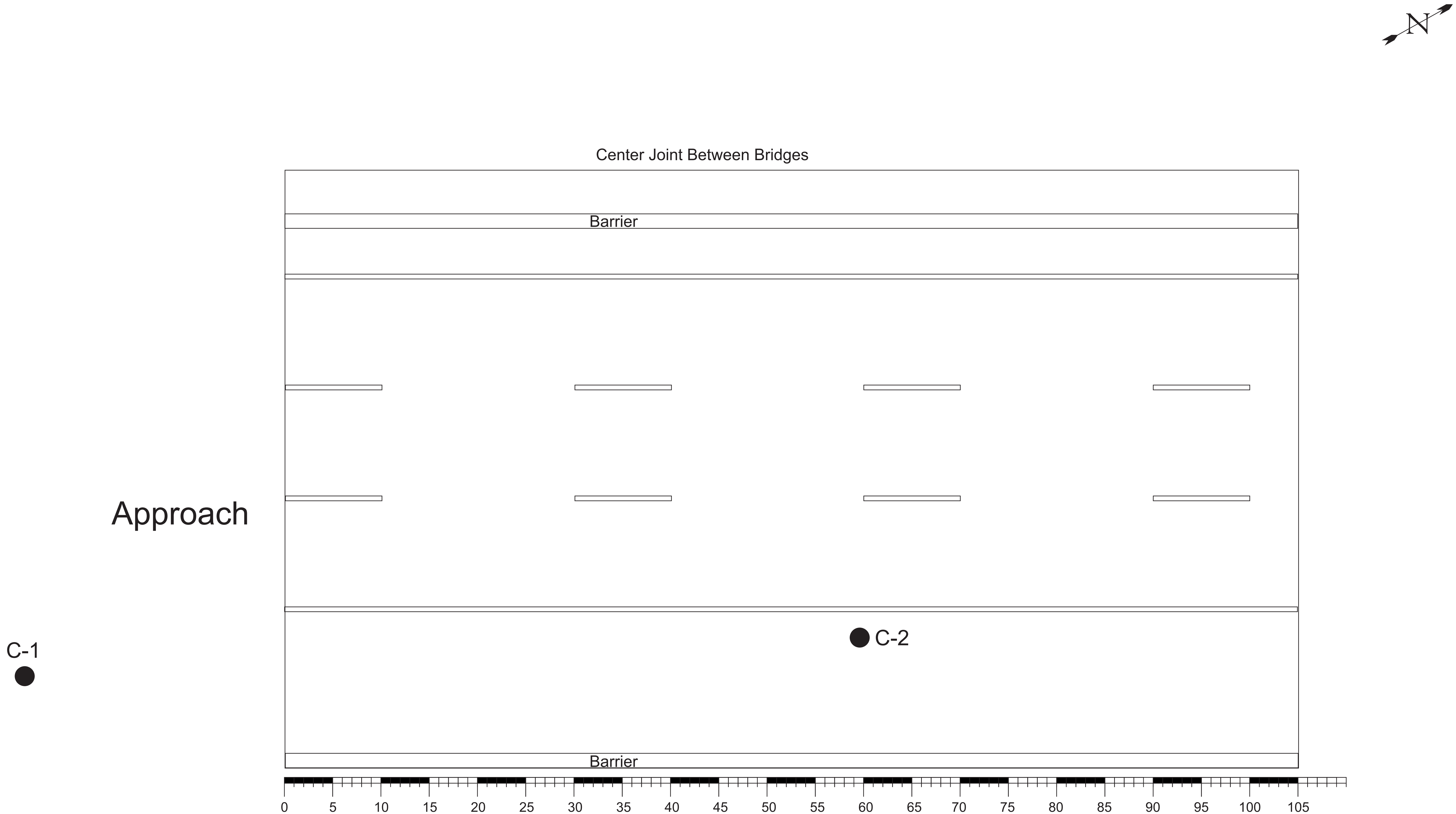
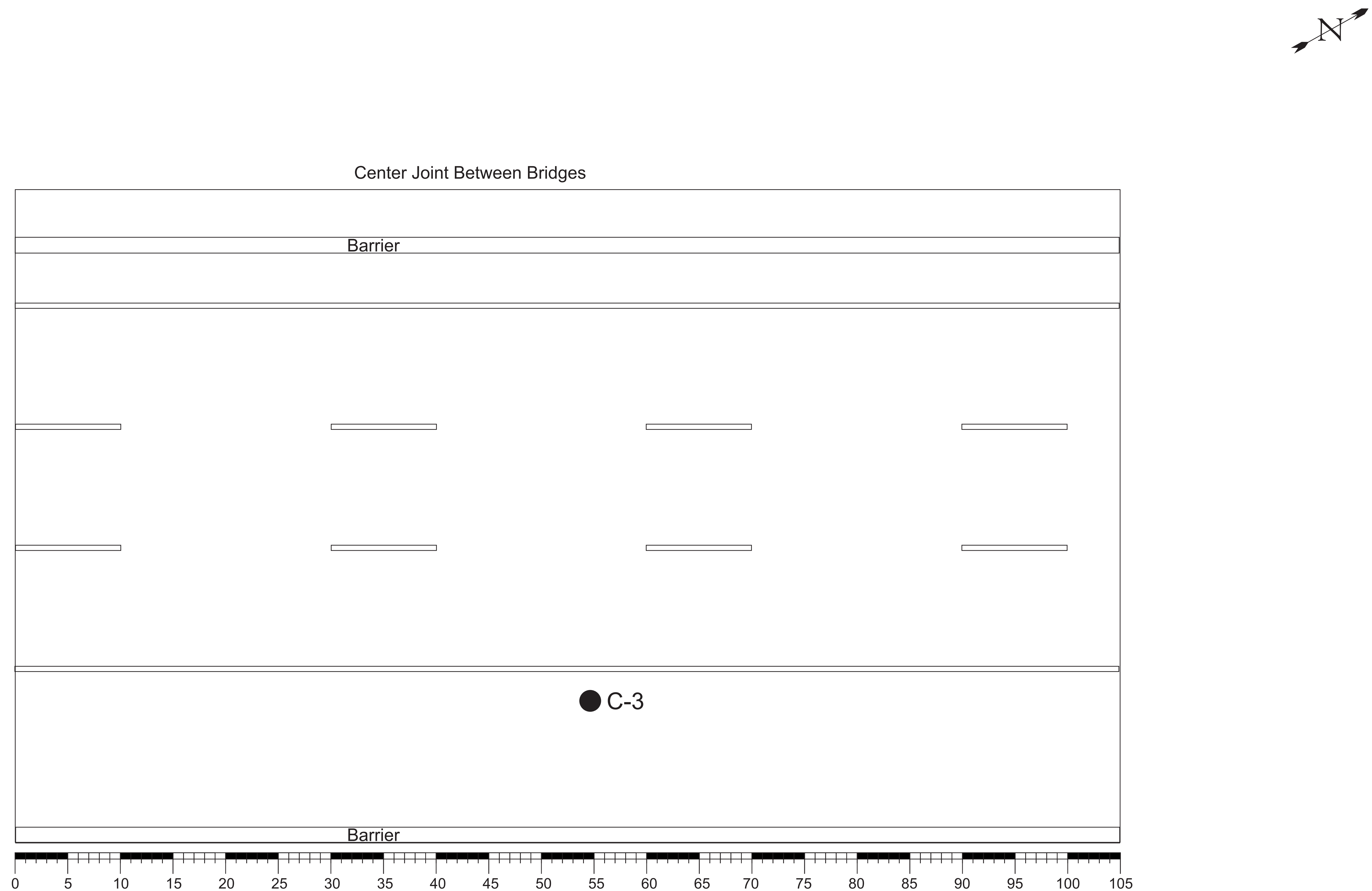


Core Locations BIN 1065149 Eastbound Span 1



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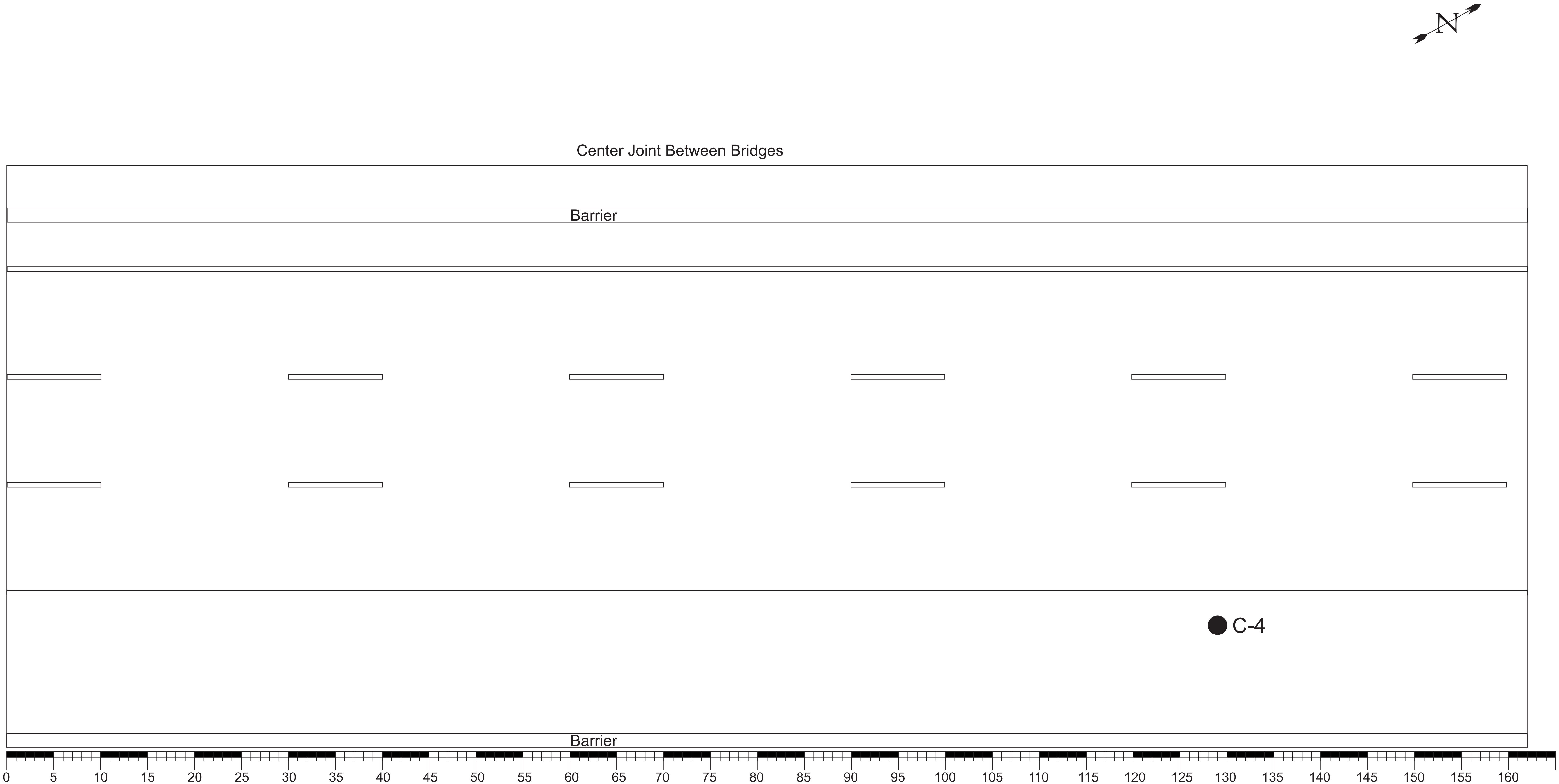

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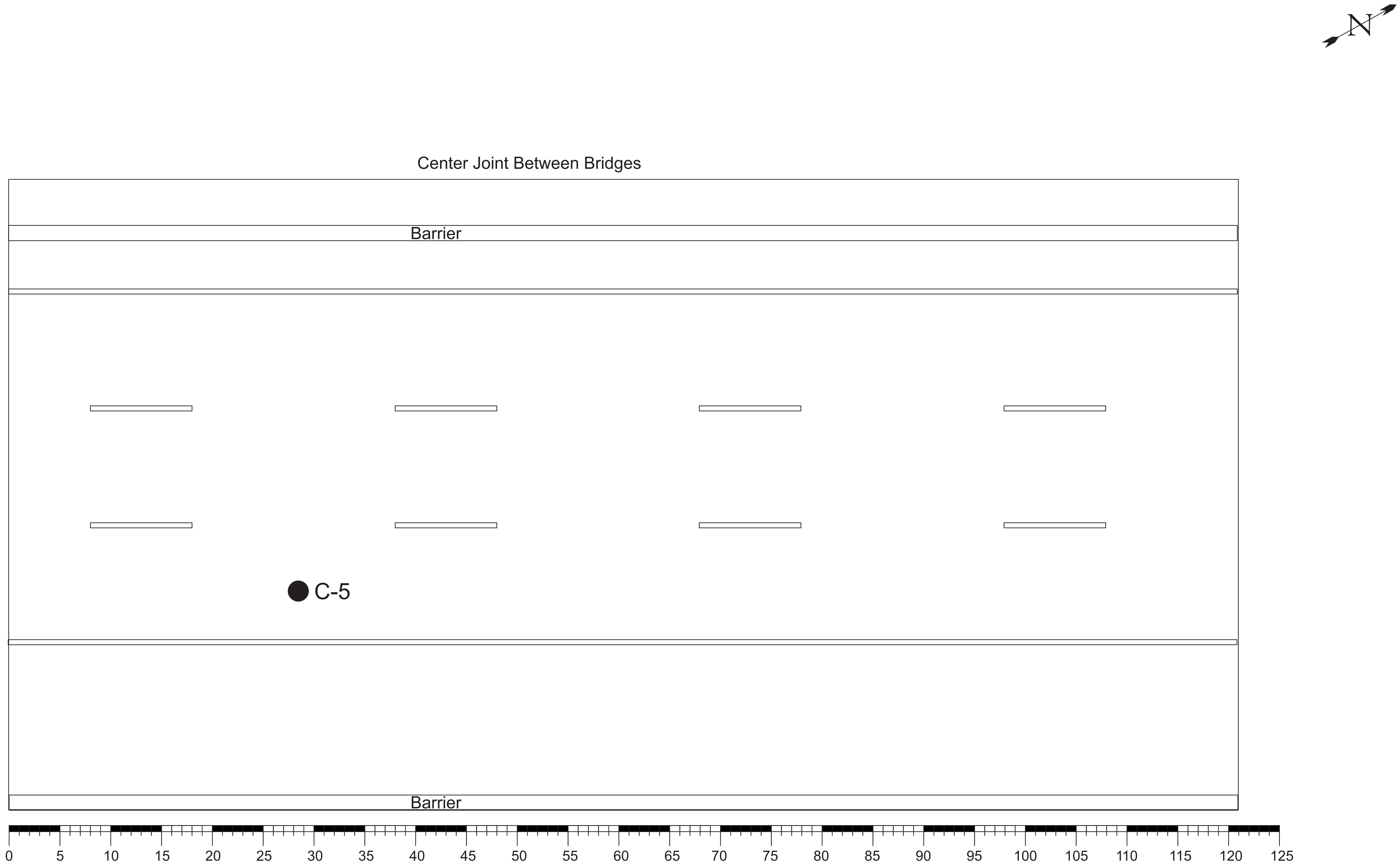

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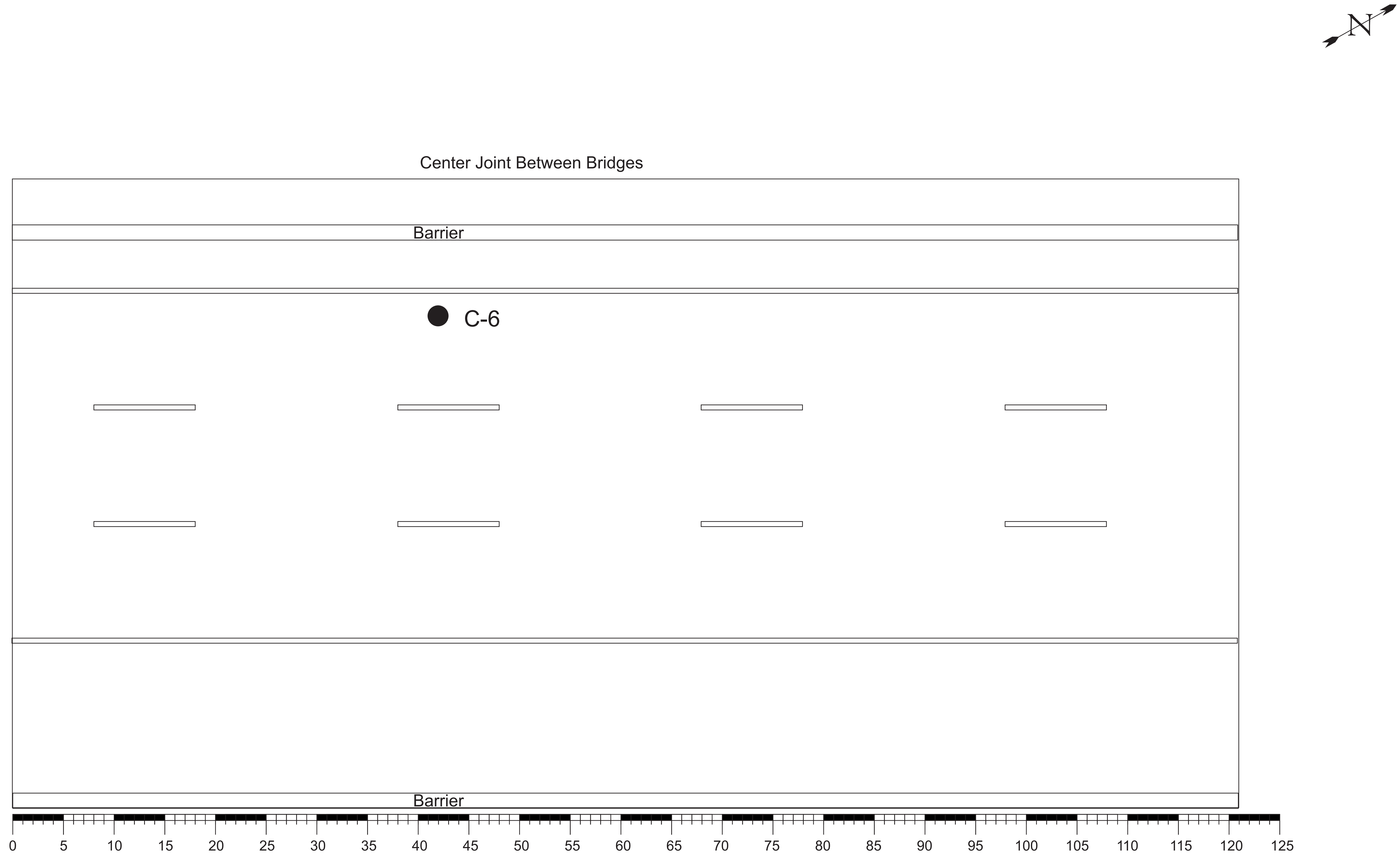

Core Locations

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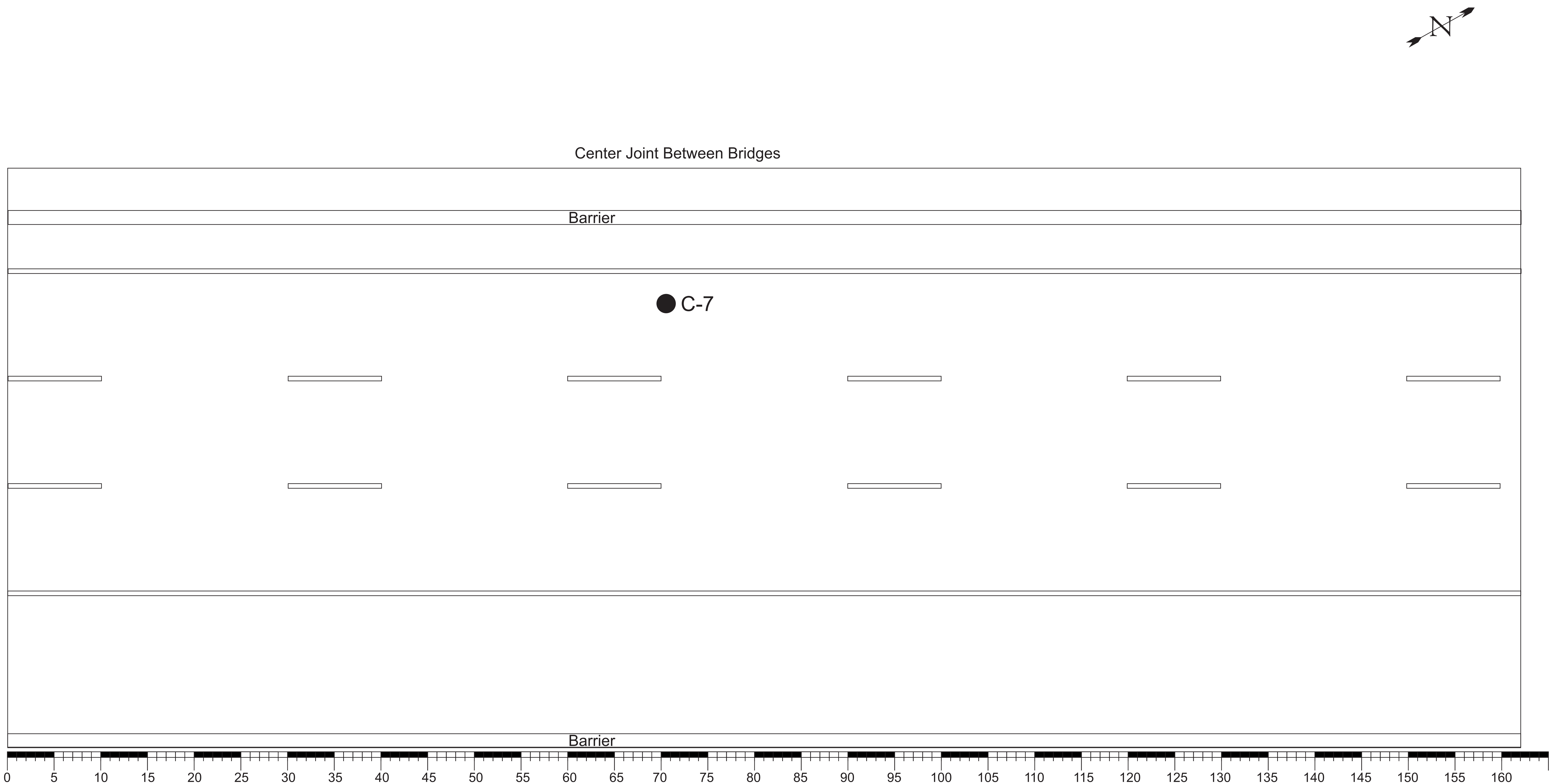

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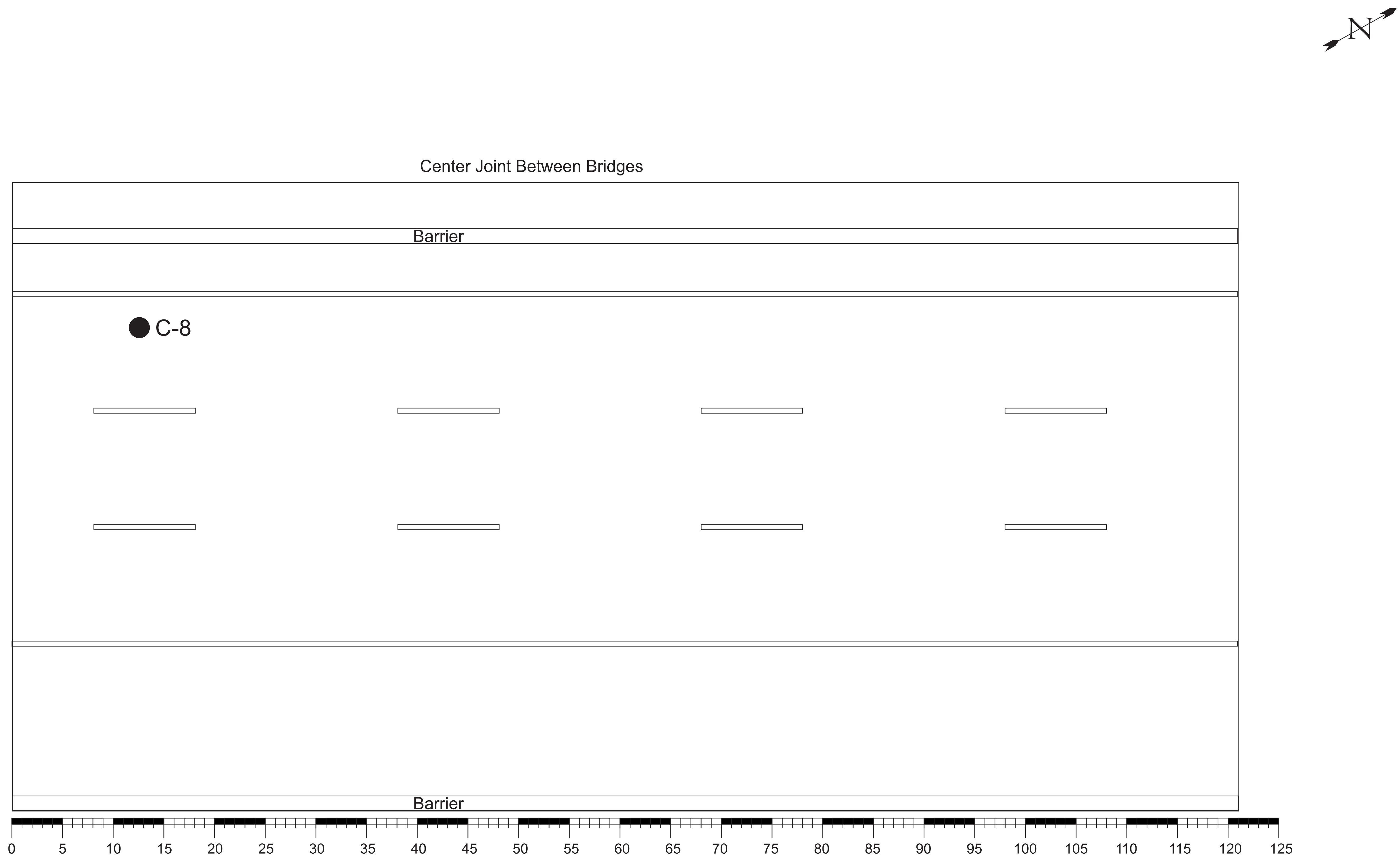

Core Locations

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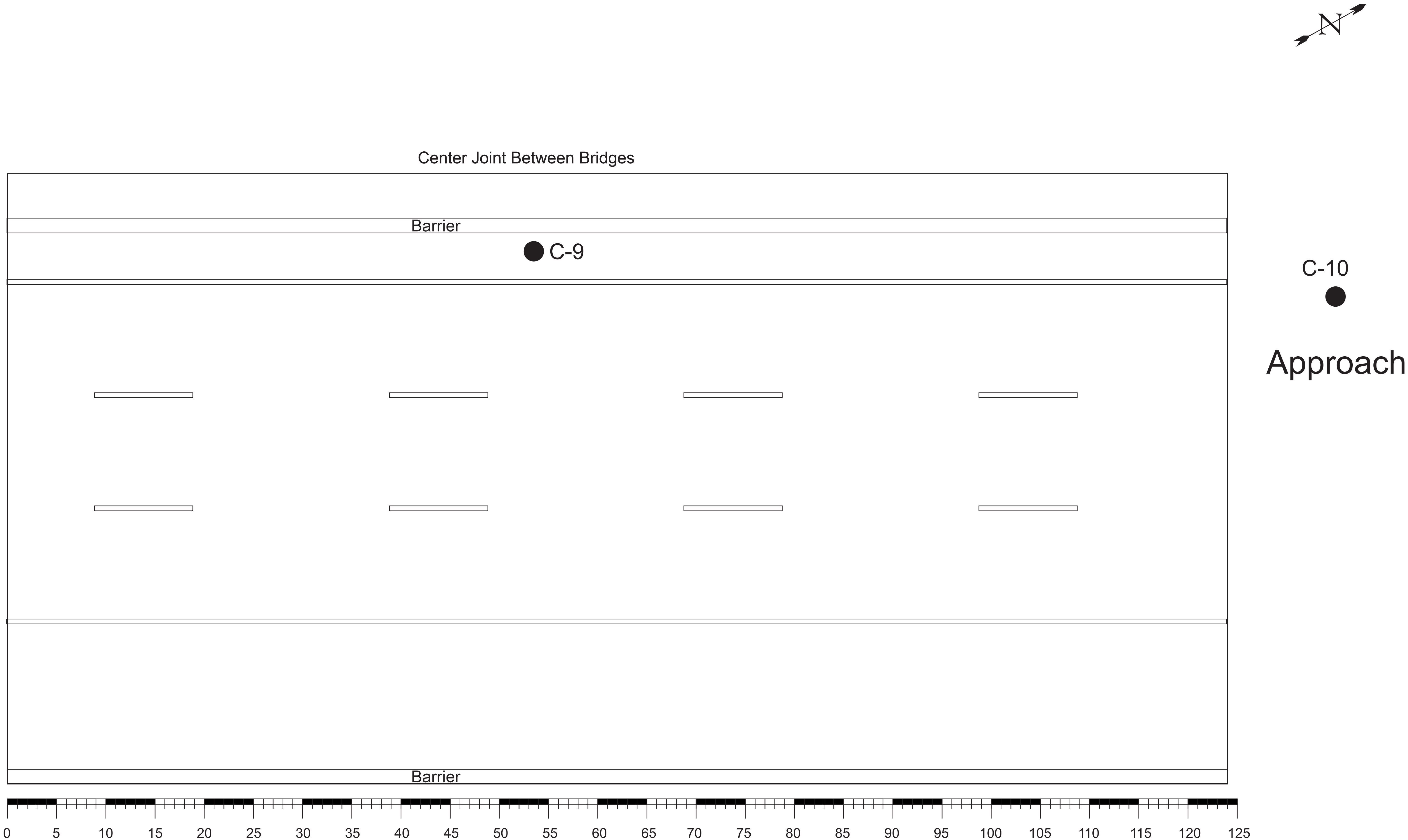

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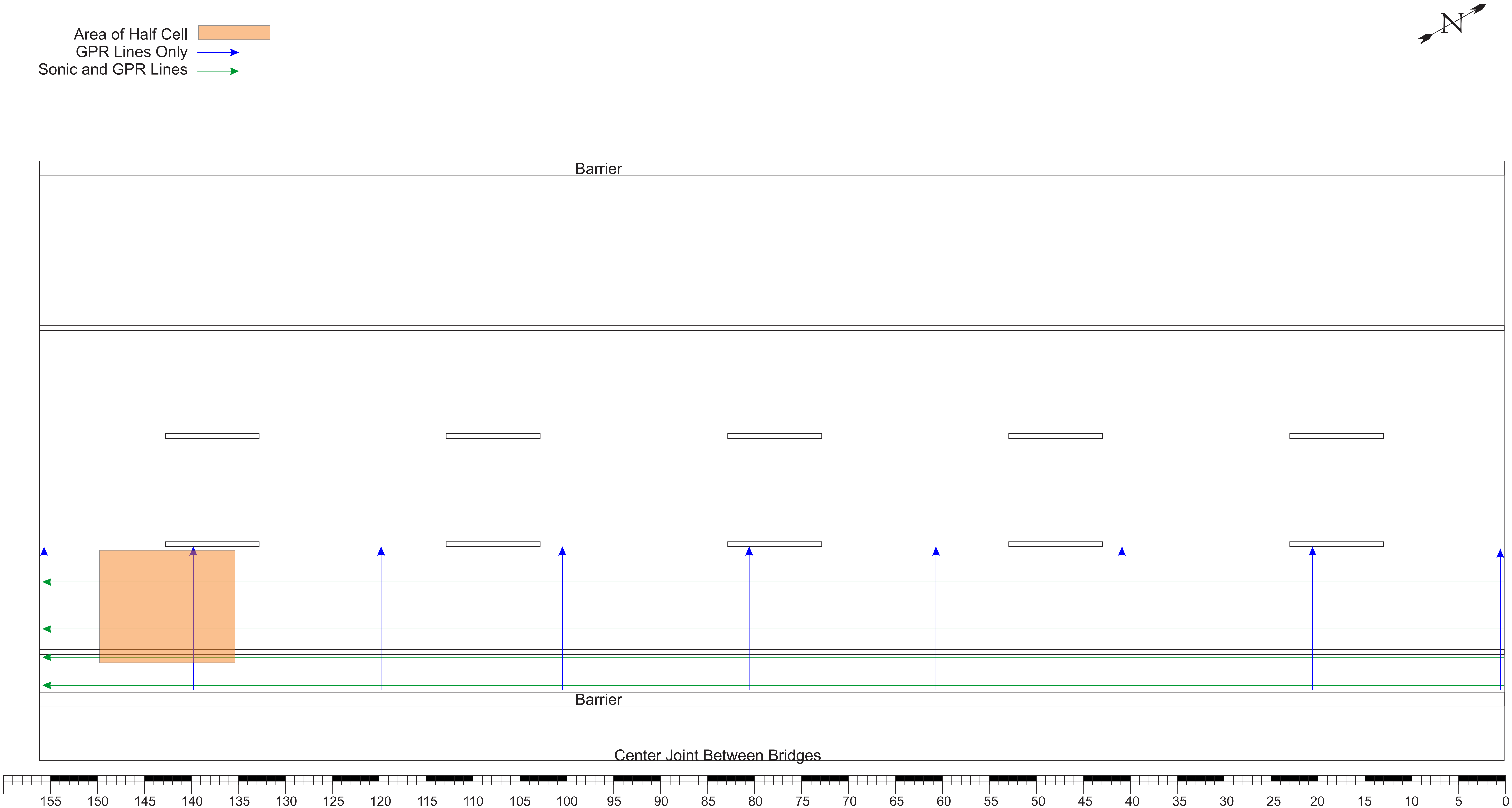
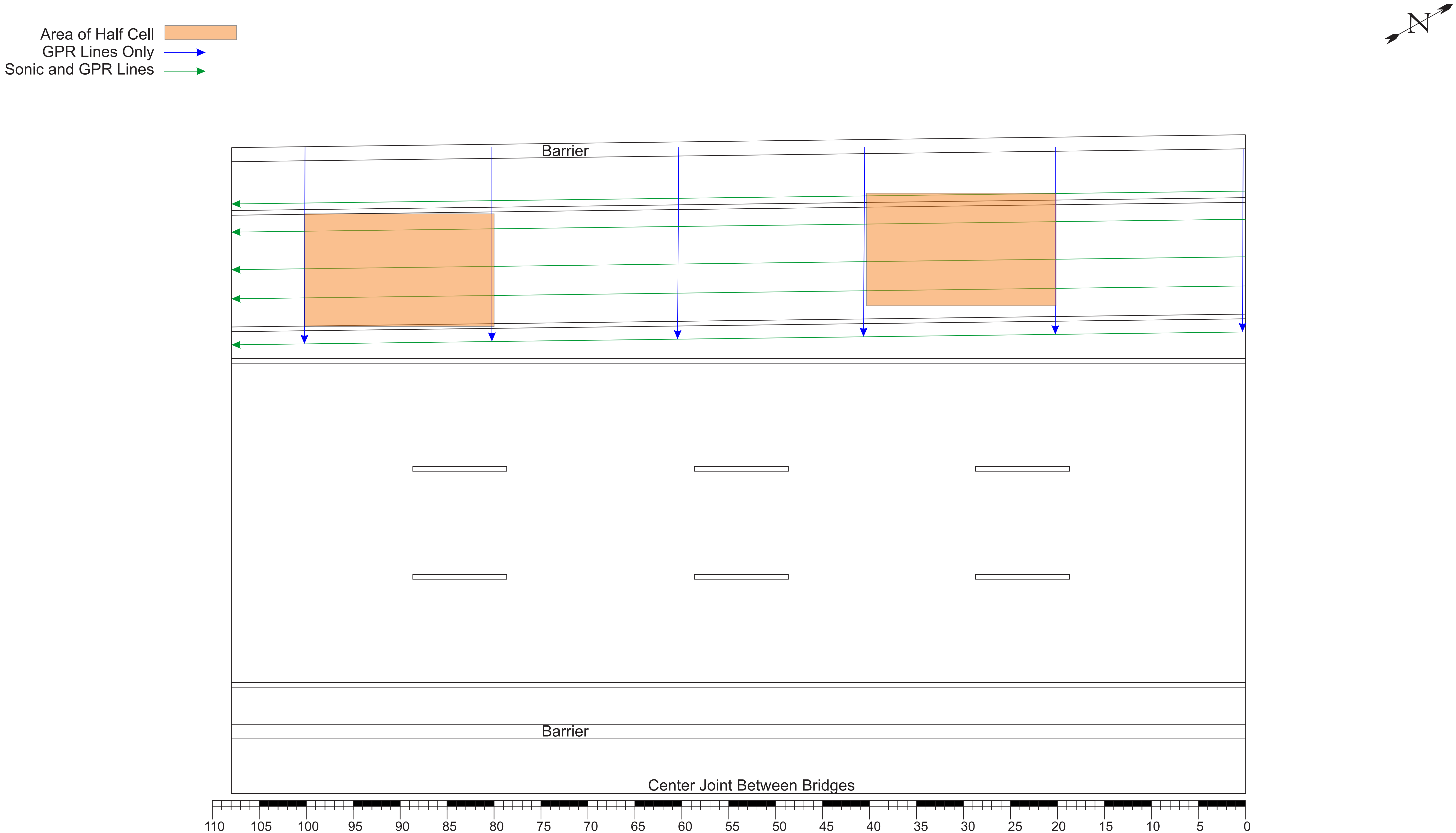


Testing Coverage BIN 1065149 Westbound Span 2



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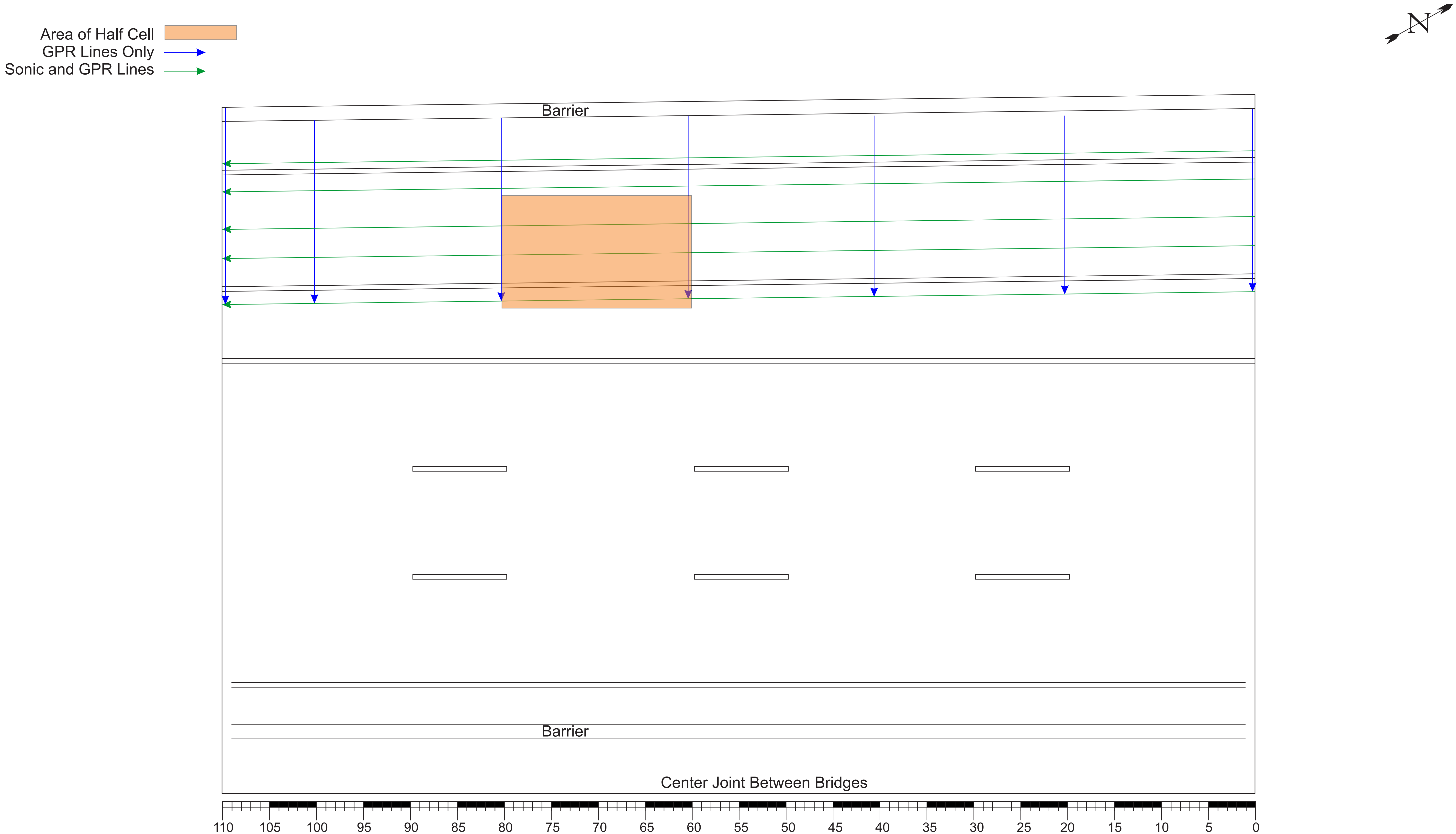

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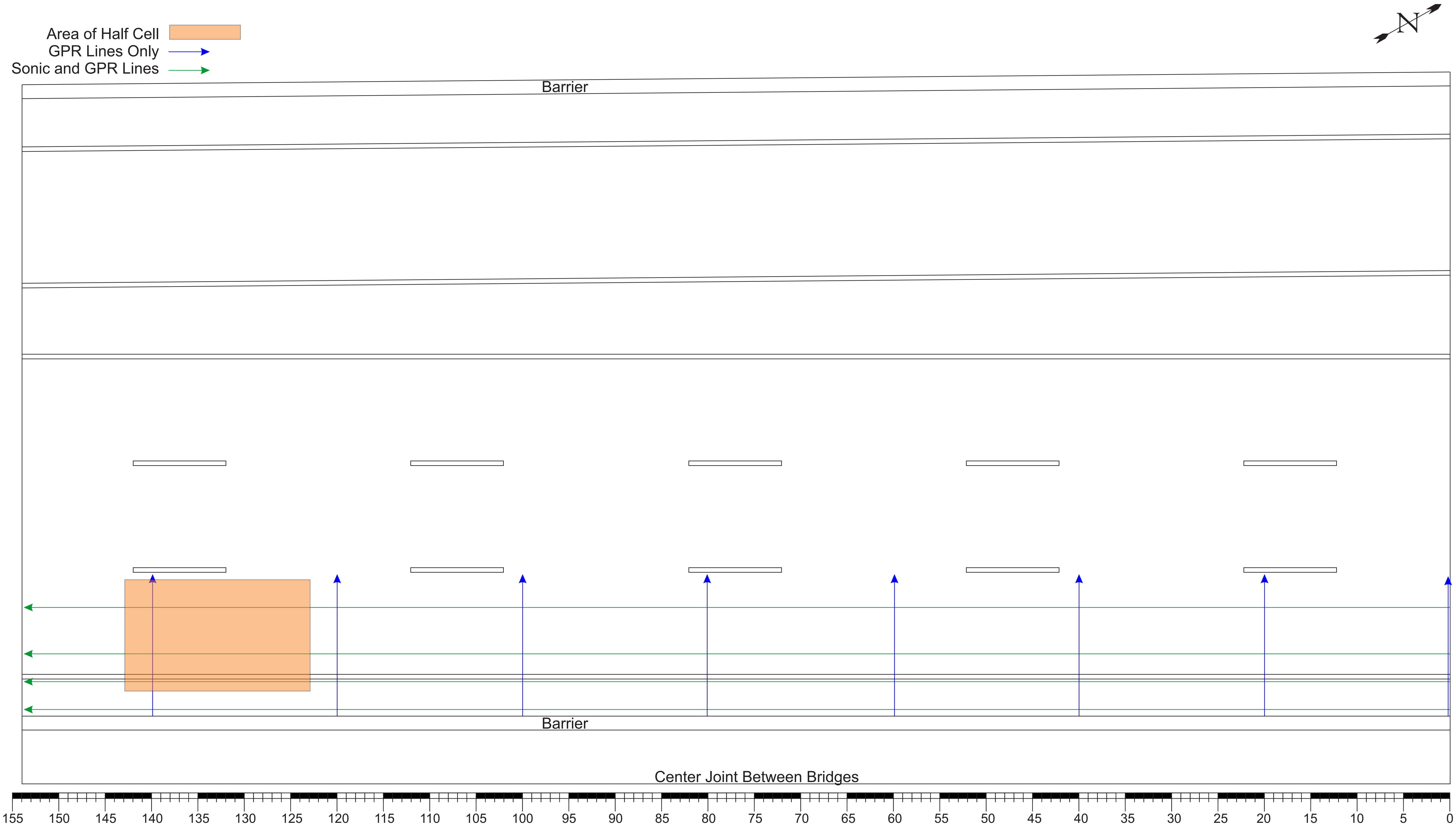
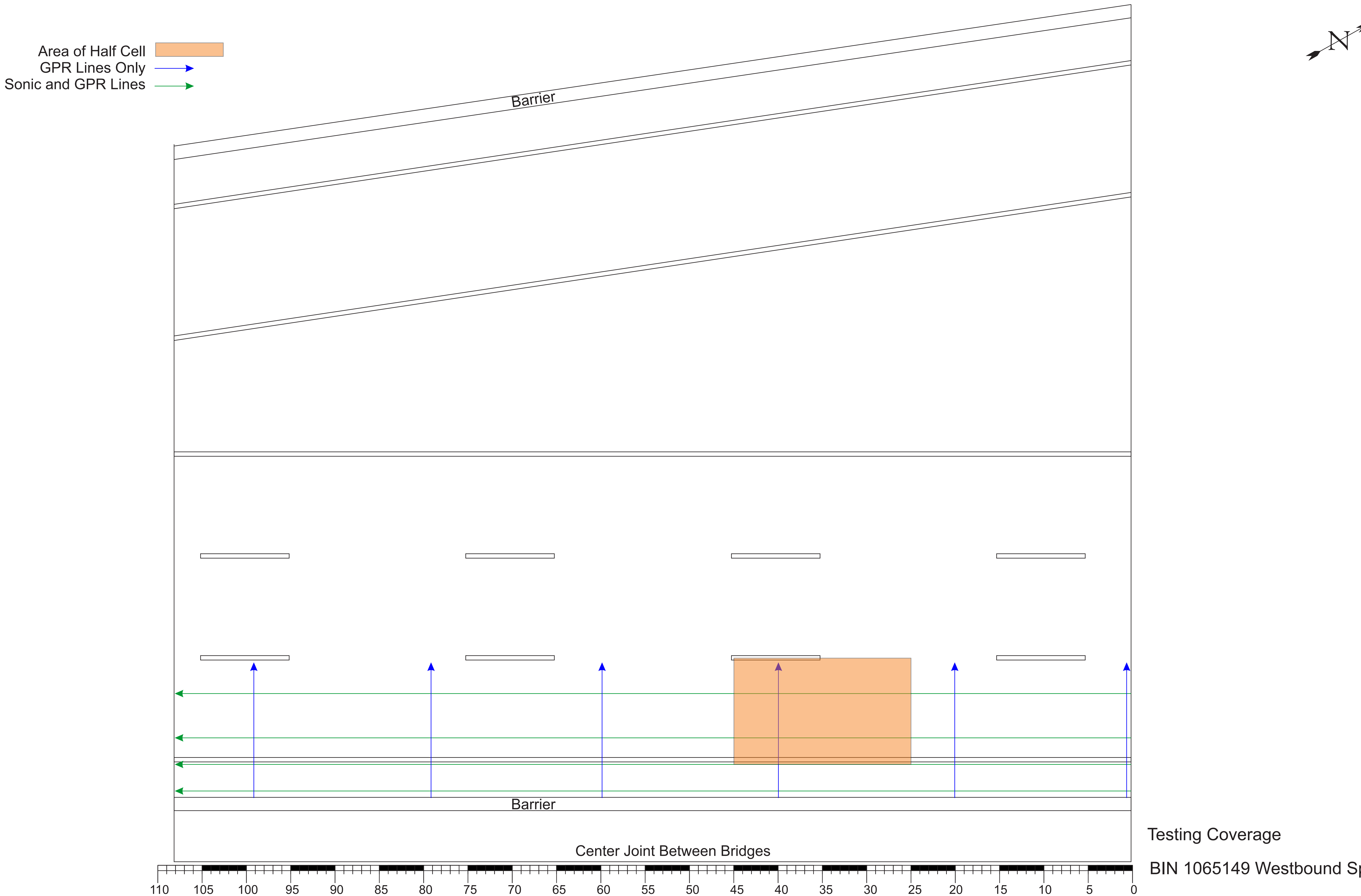
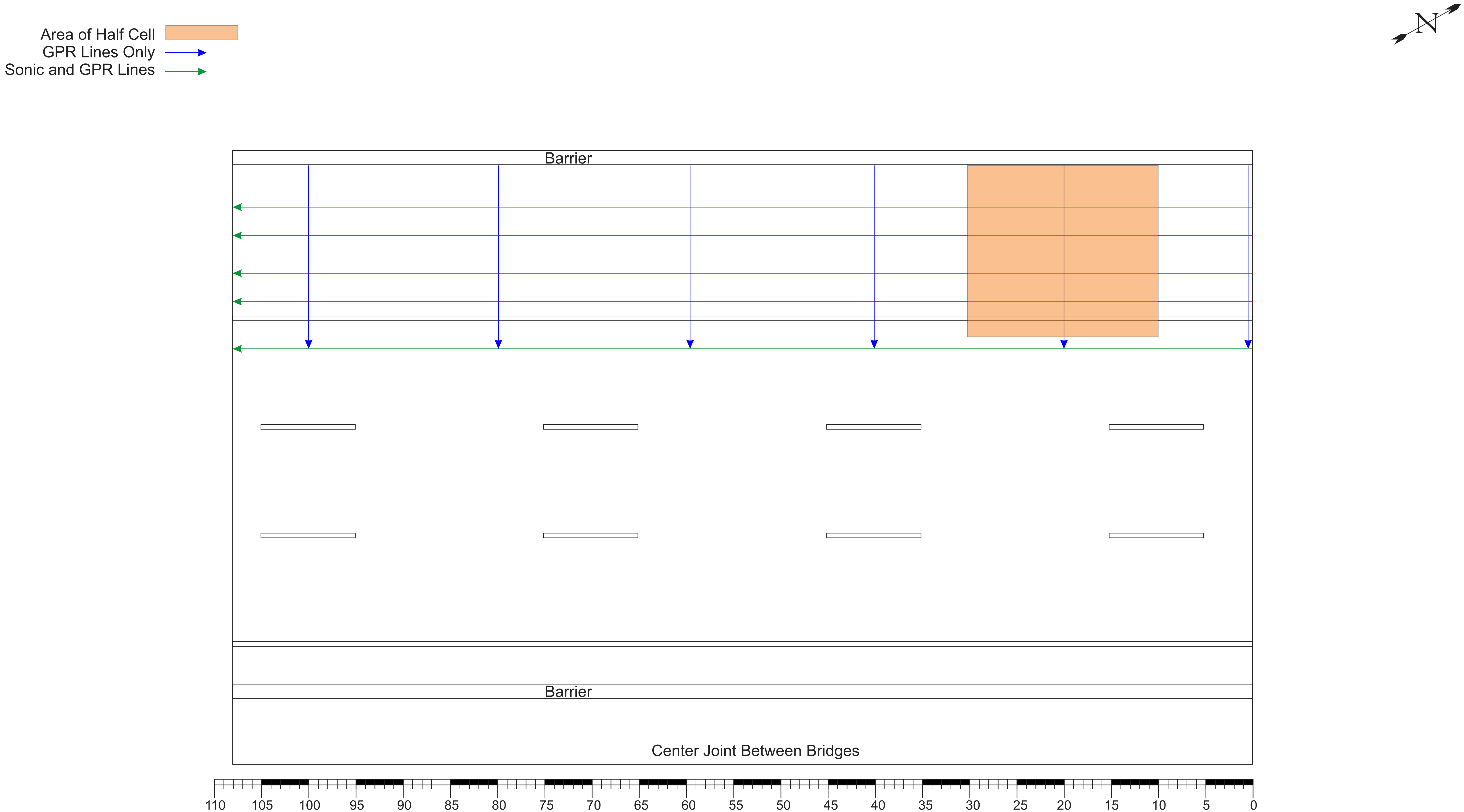


Testing Coverage BIN 1065149 Westbound Span 8



Testing Coverage

BIN 1065149 Westbound Span 10



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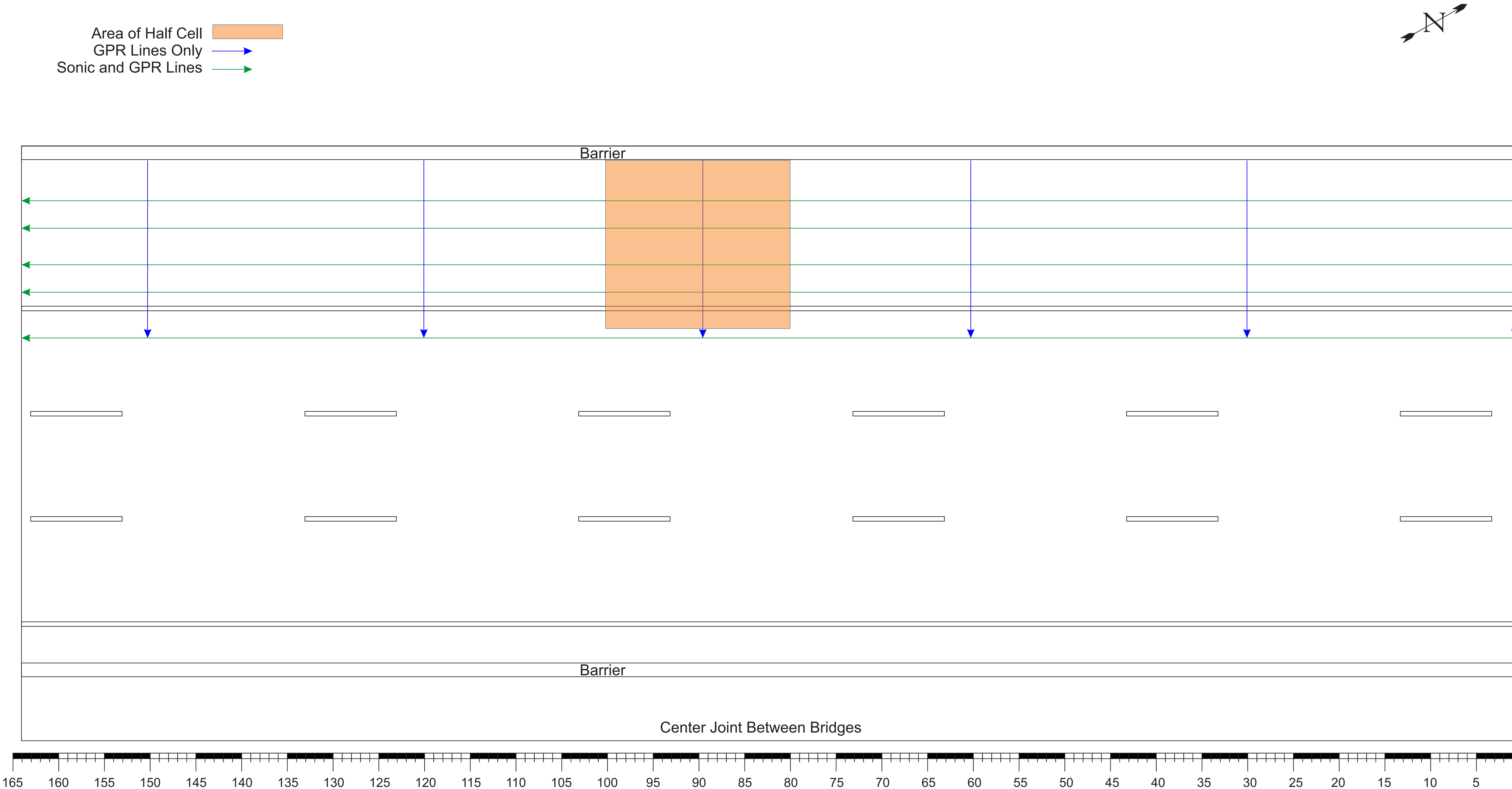

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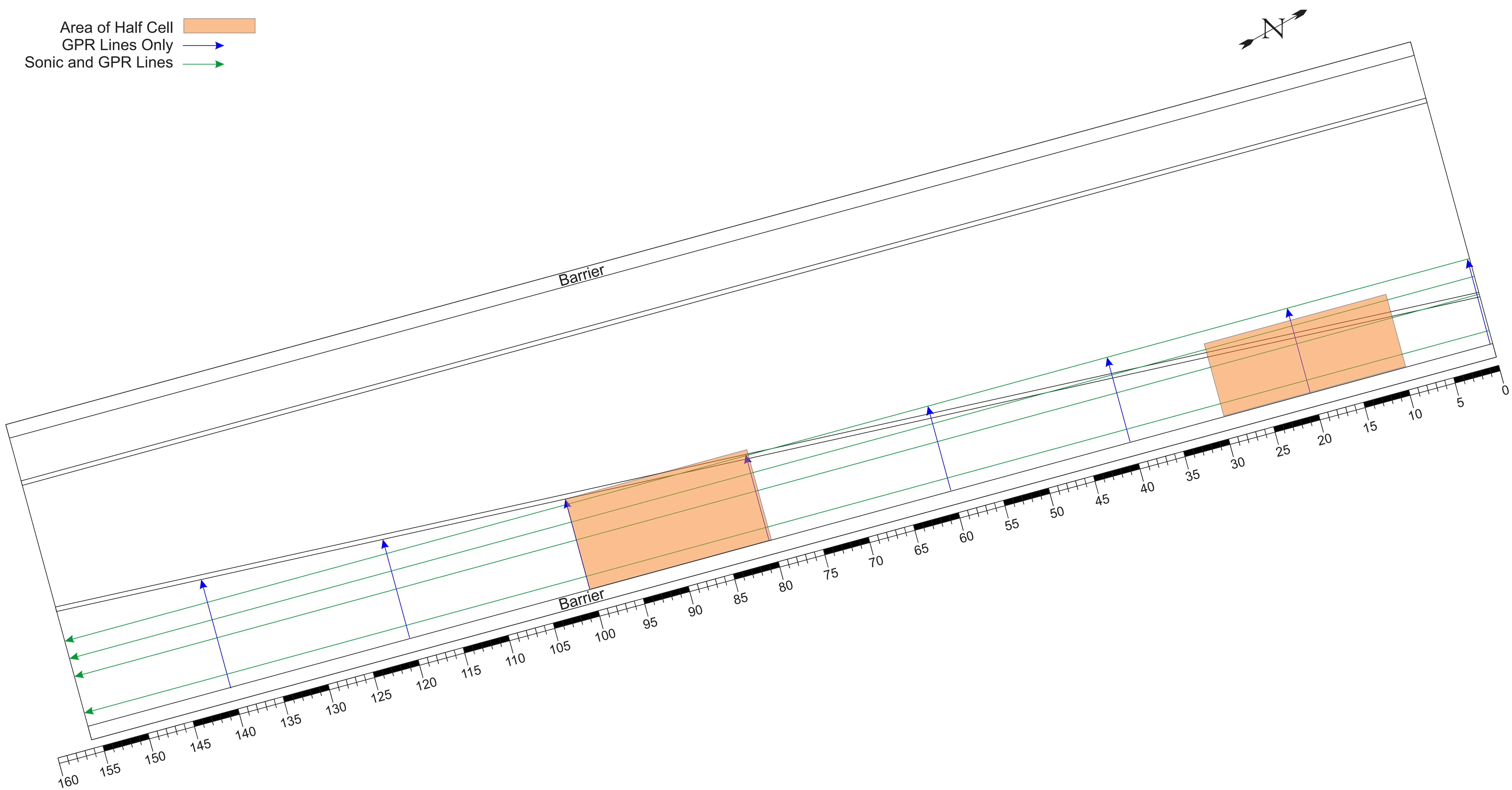
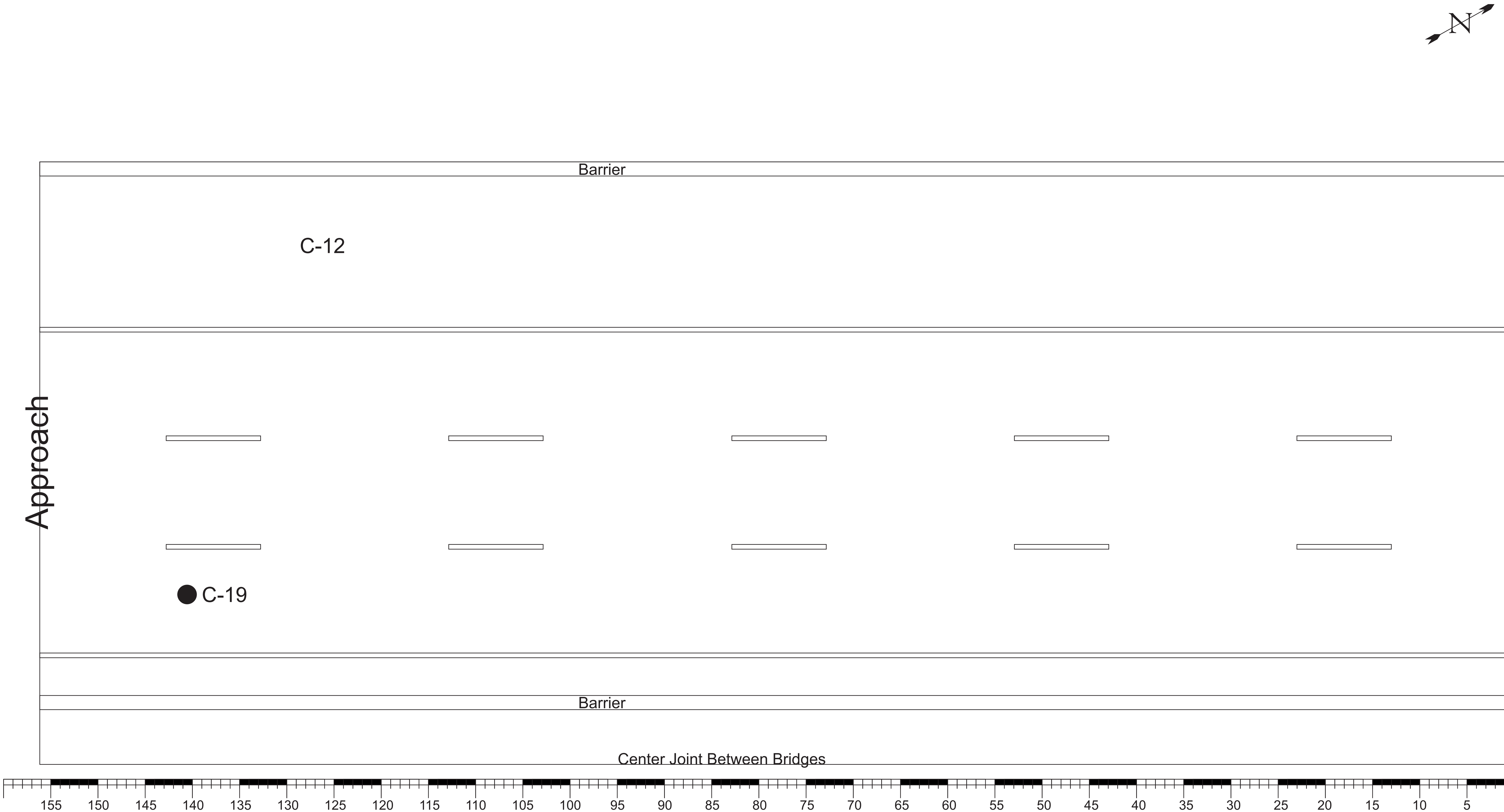
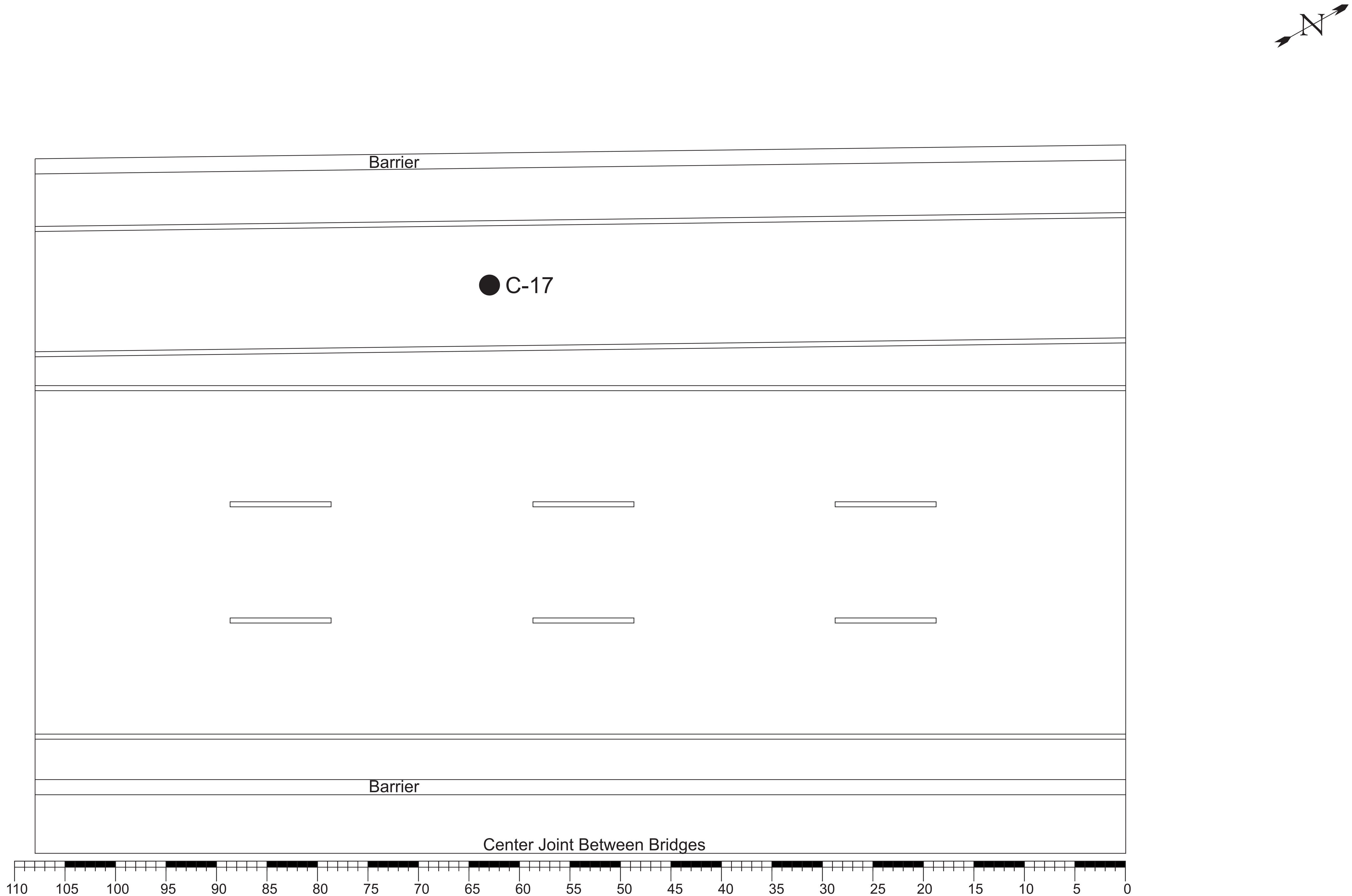


Testing Coverage BIN 106514A Ramp H



C-18 West Approach is12.5 feet South of the North Barrier and 19 feet West of West abutment.

Core Locations BIN 1065149 Westbound Span 2



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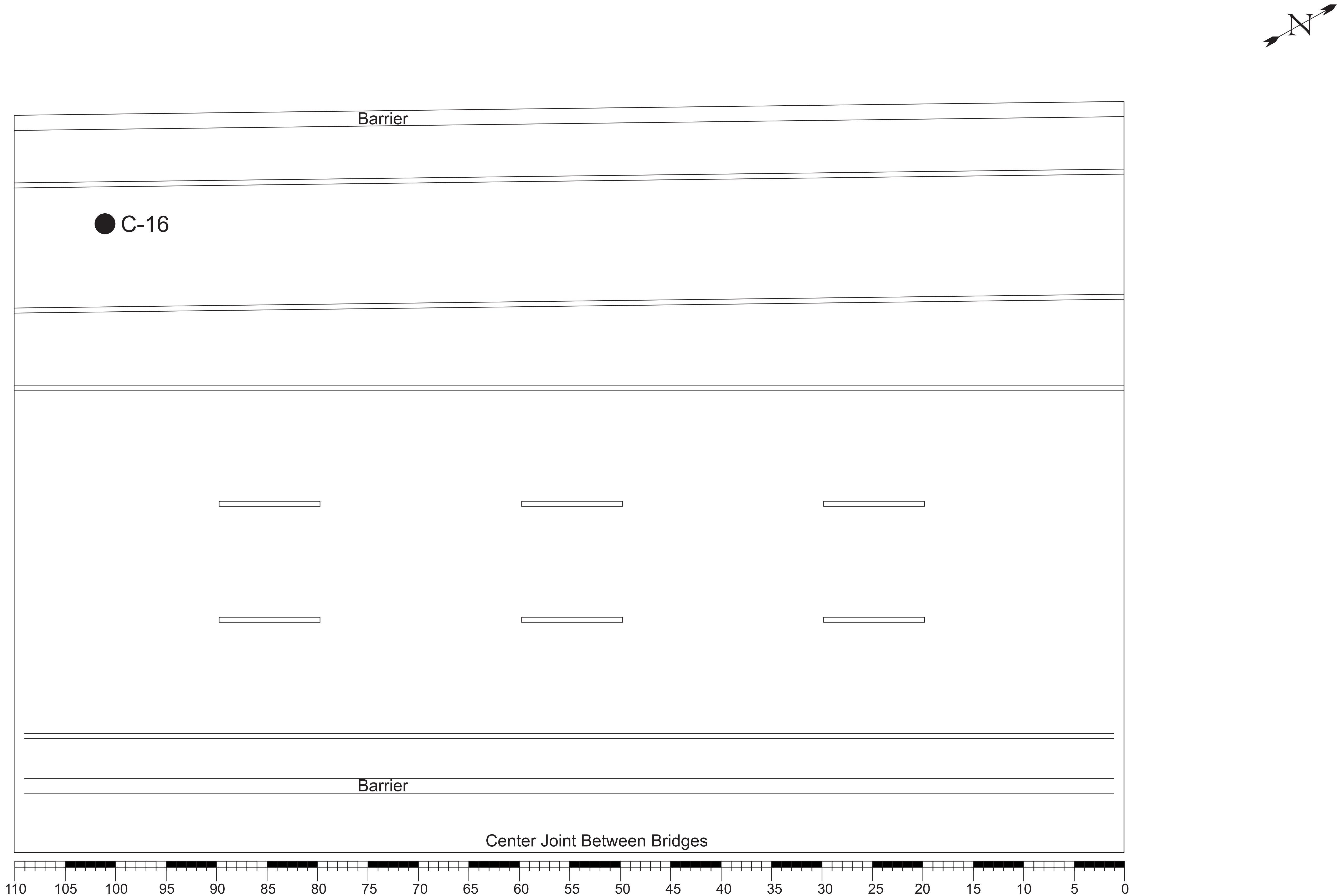

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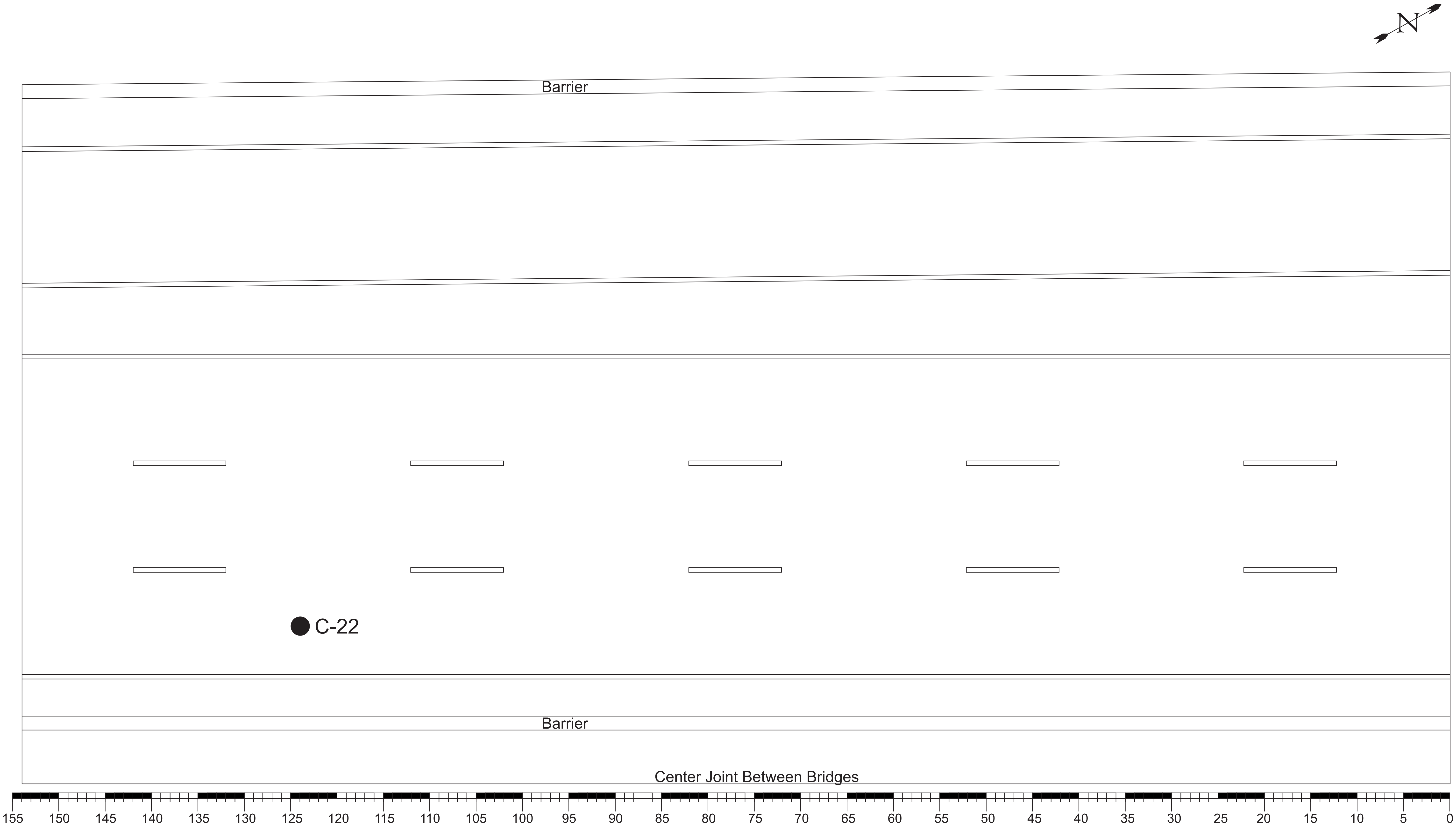
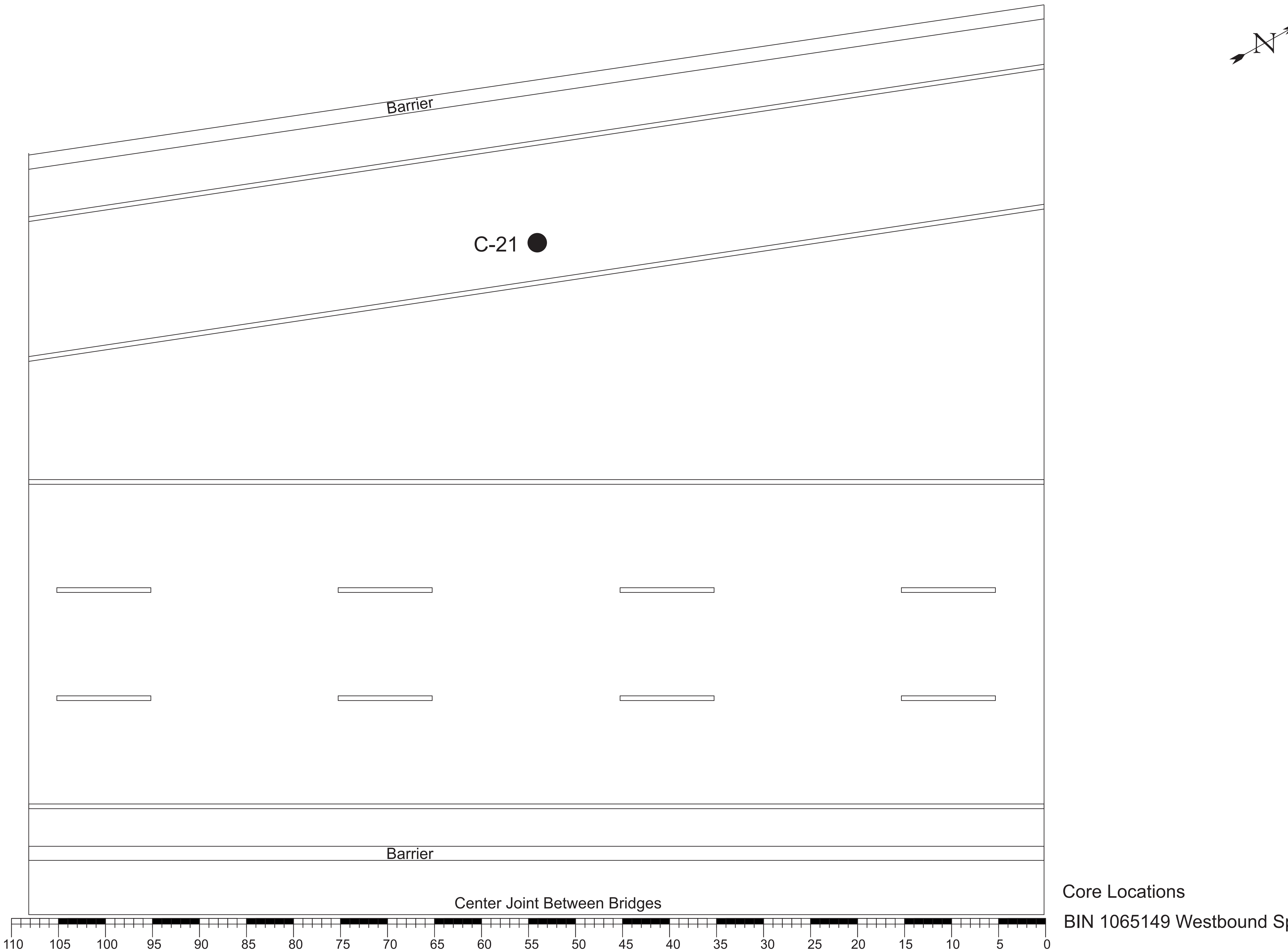
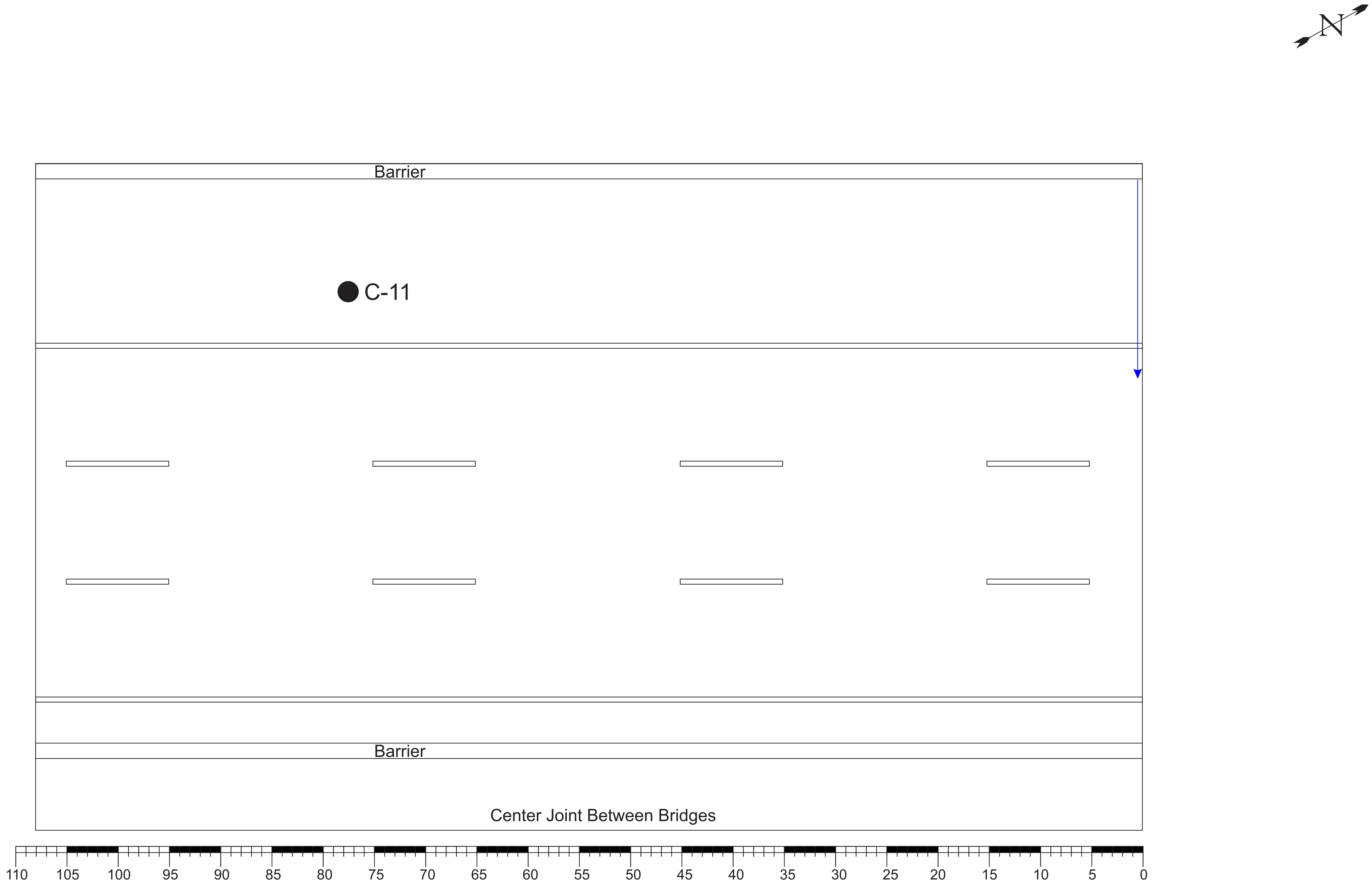


Core Locations BIN 1065149 Westbound Span 8



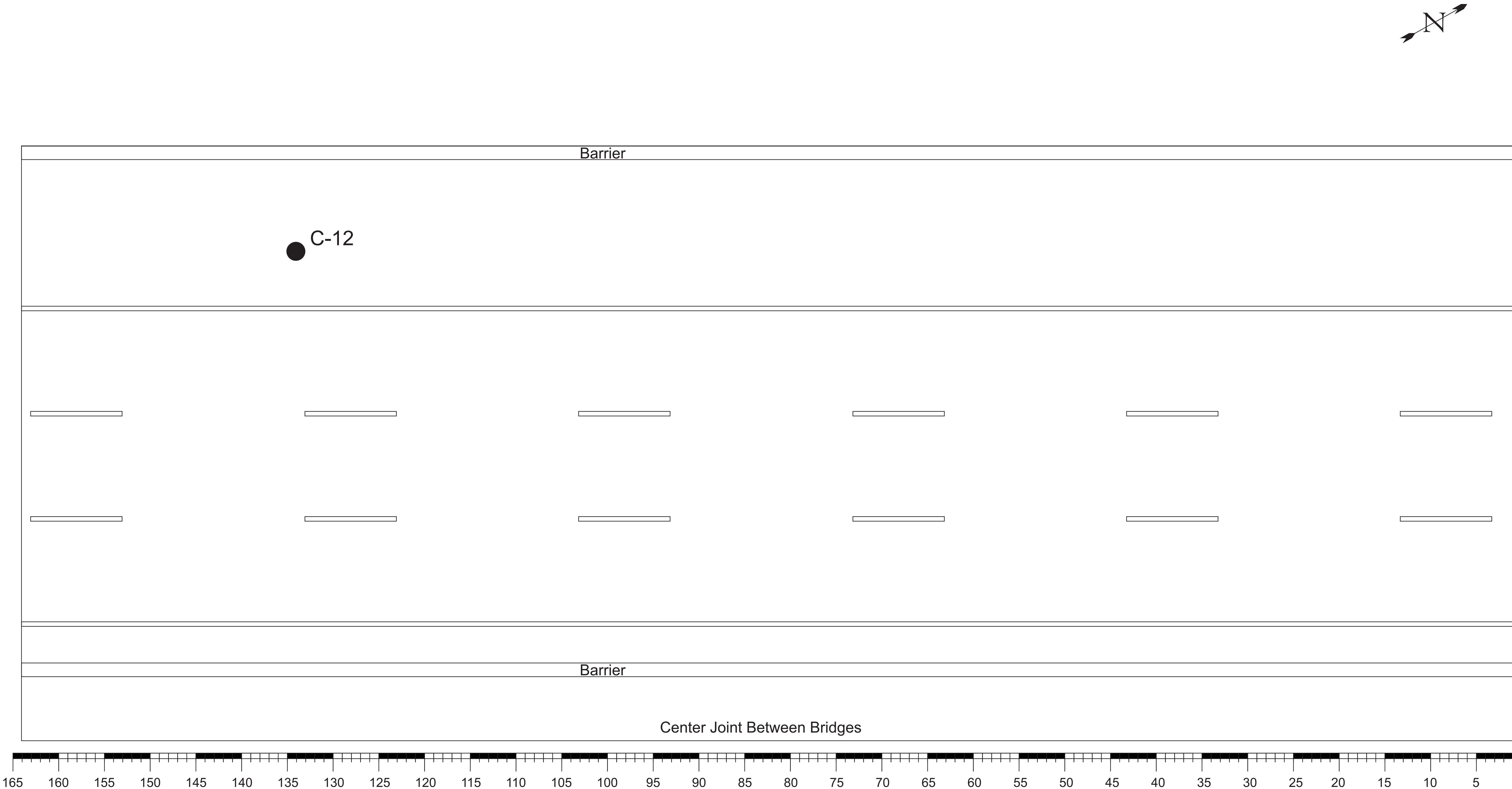
Core Locations

BIN 1065149 Westbound Span 10



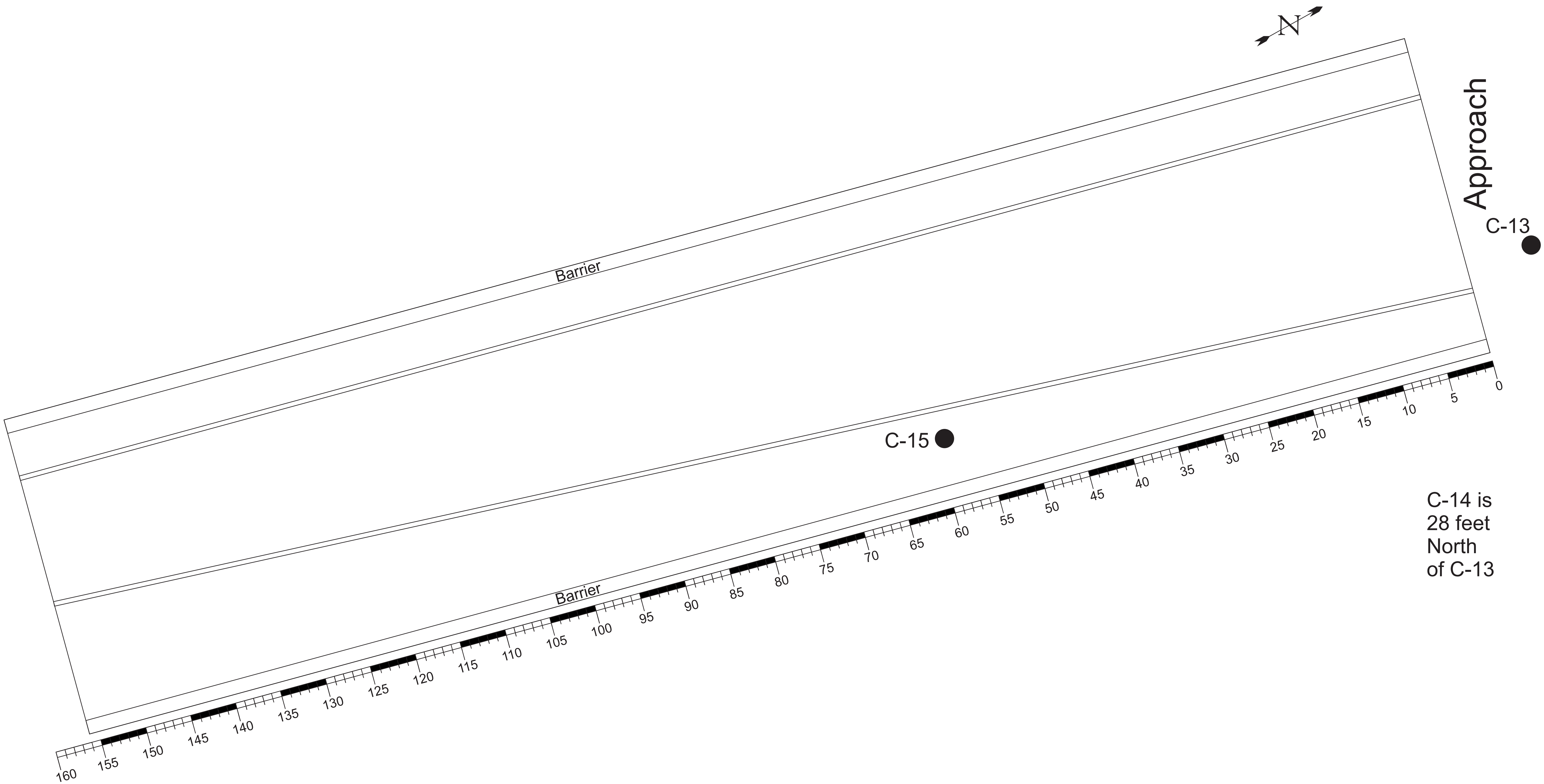
Core Locations

BIN 1065149 Westbound Span 12



C-20 East Approach is16.5 feet North of the center joint and 12 feet East of East abutment.

Core Locations BIN 1065149 Westbound Span 14



Core Locations BIN 106514A Ramp H

Appendix B
Impact Echo/Pulse Velocity Survey Maps

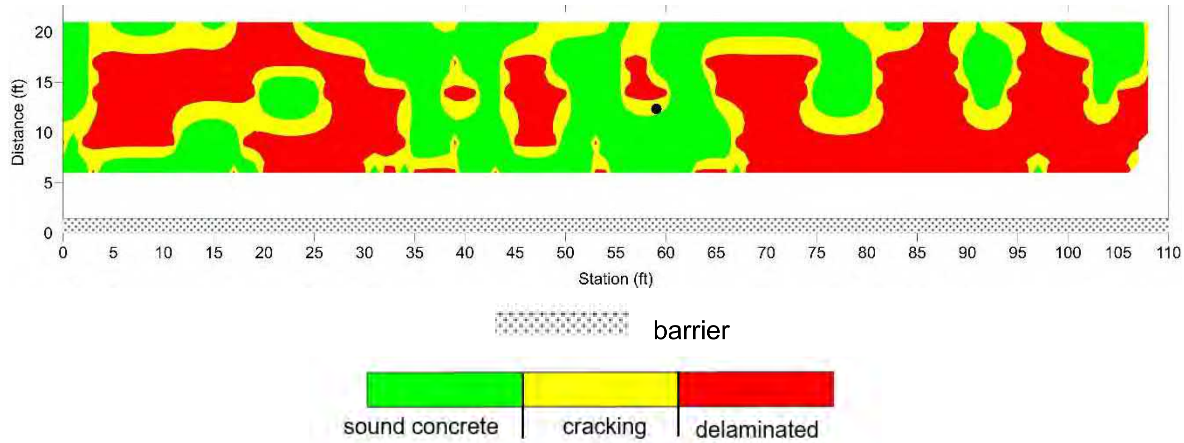


Figure B-1: IE/PV Survey Map for Span 1 Eastbound Slow Lane

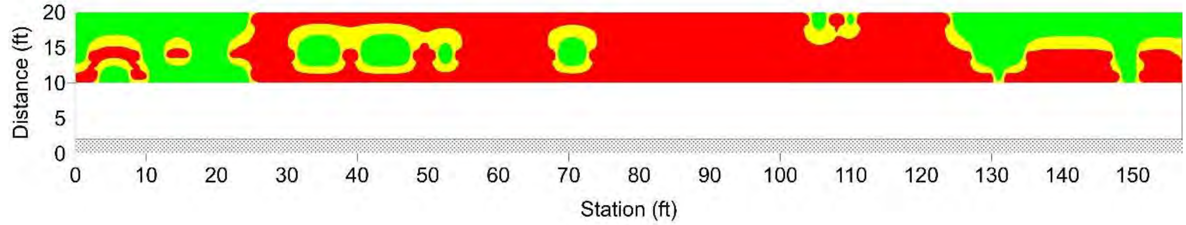


Figure B-2: IE/PV Survey Map for Span 2 Westbound Fast Lane

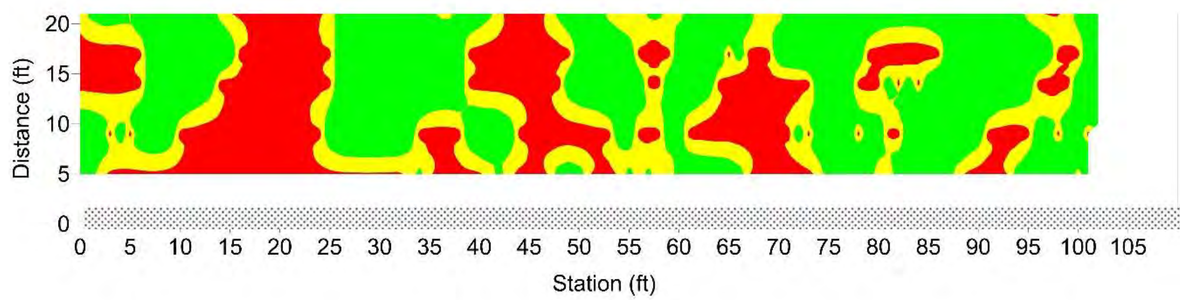


Figure B-3: IE/PV Survey Map for Span 3 Eastbound Slow Lane

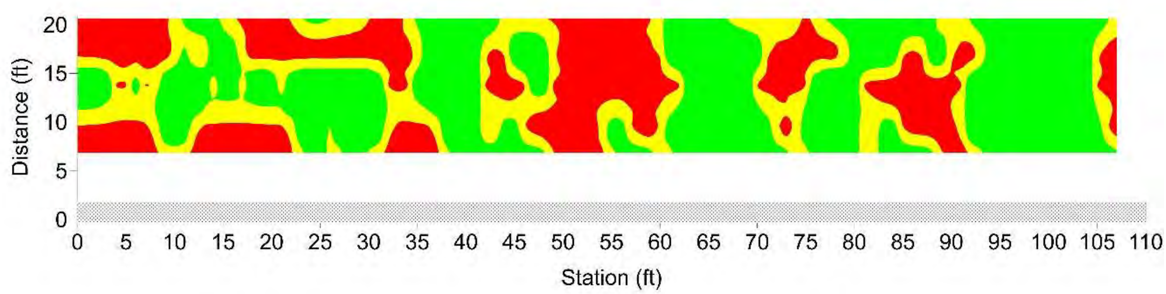


Figure B-4: IE/PV Survey Map for Span 4 Westbound Slow Lane

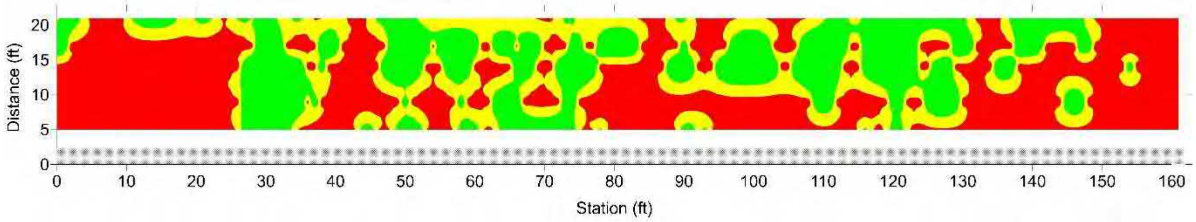


Figure B-5: IE/PV Survey Map for Span 5 Eastbound Slow Lane

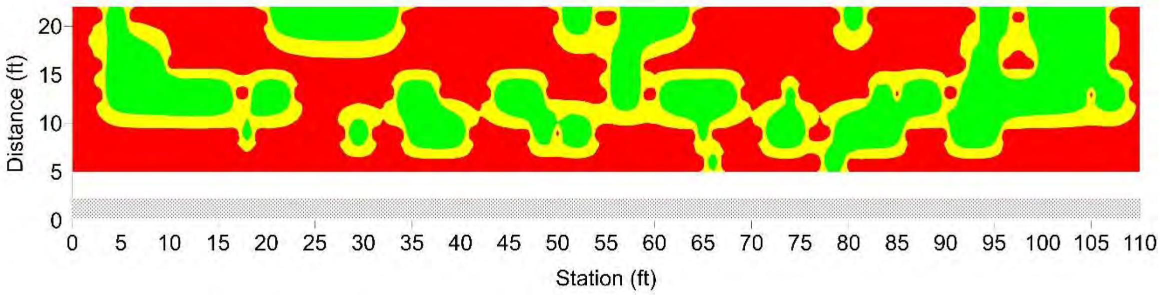


Figure B-6: IE/PV Survey Map for Span 6 Westbound Slow Lane

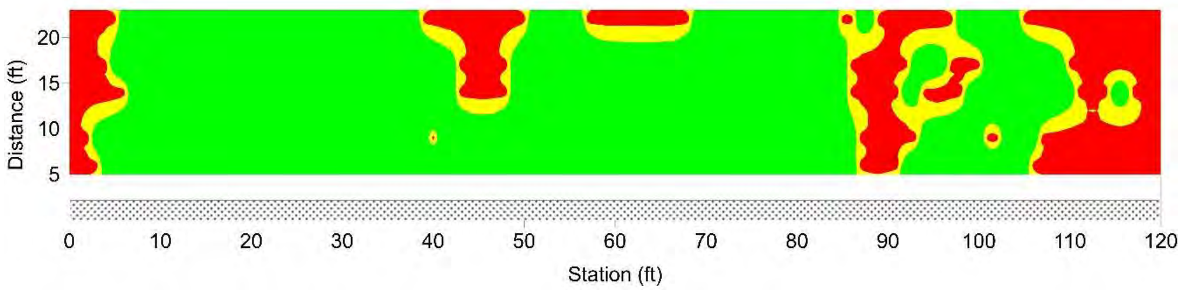


Figure B-7: IE/PV Survey Map for Span 7 Eastbound Slow Lane

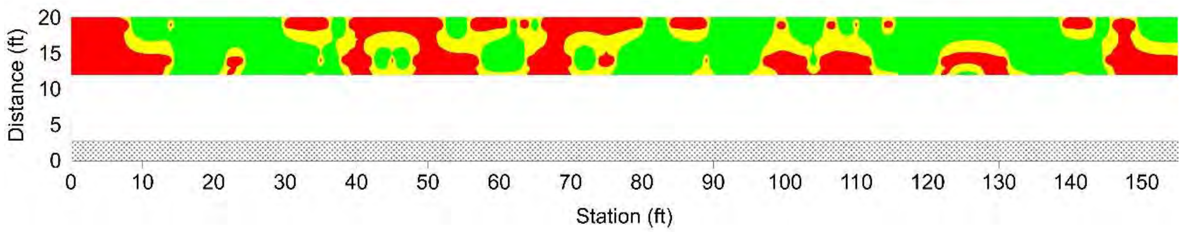


Figure B-8: IE/PV Survey Map for Span 8 Westbound Fast Lane

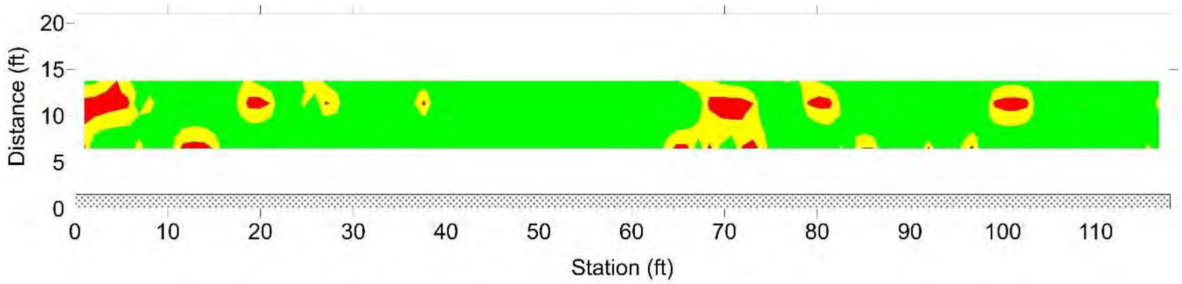


Figure B-9: IE/PV Survey Map for Span 9 Eastbound Fast Lane

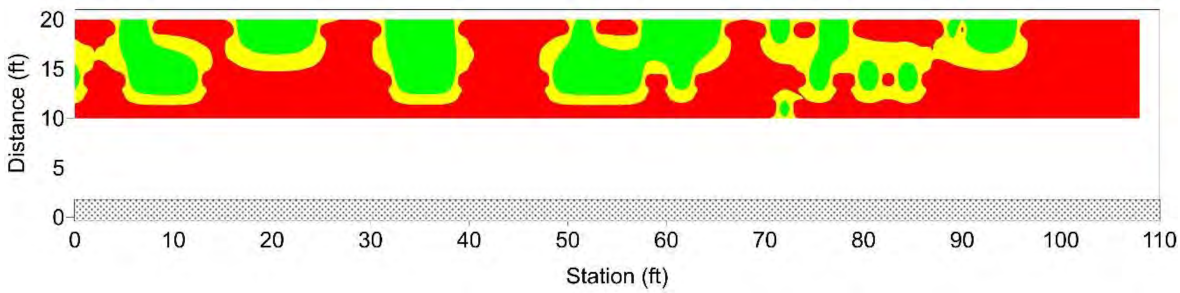


Figure B-10: IE/PV Survey Map for Span 10 Westbound Fast Lane

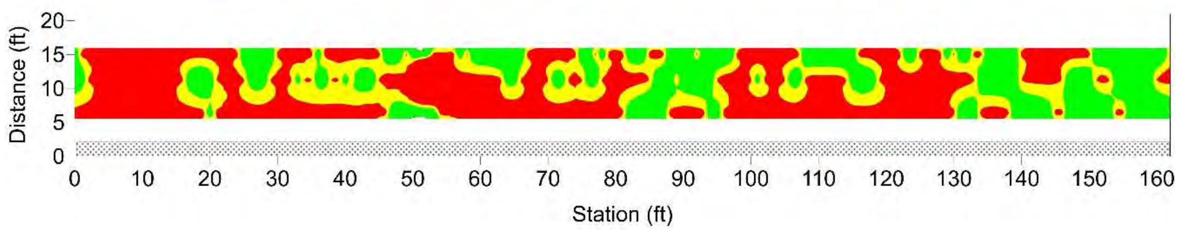


Figure B-11: IE/PV Survey Map for Span 11 Eastbound Fast Lane

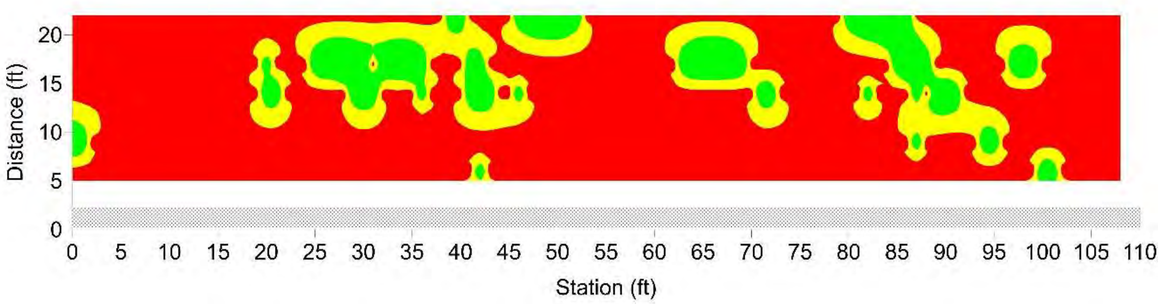


Figure B-12: IE/PV Survey Map for Span 12 Westbound Slow Lane

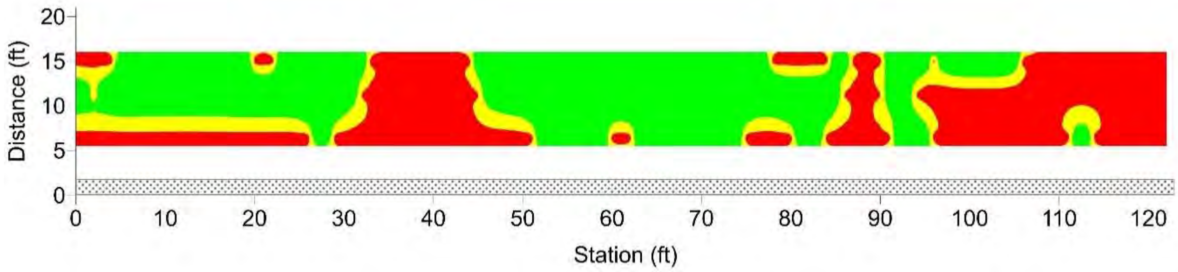


Figure B-13: IE/PV Survey Map for Span 13 Eastbound Fast Lane

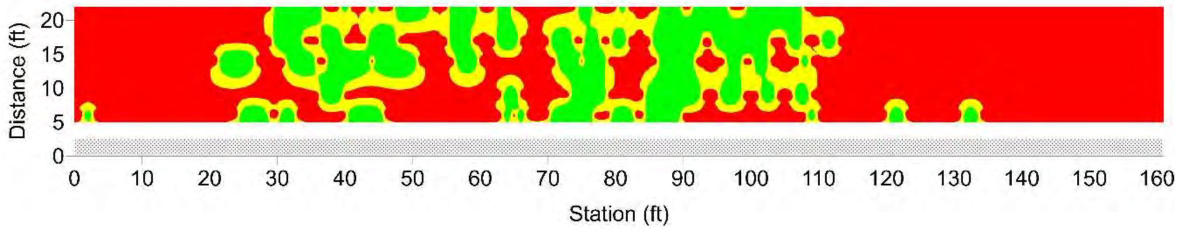


Figure B-14: IE/PV Survey Map for Span 14 Westbound Slow Lane

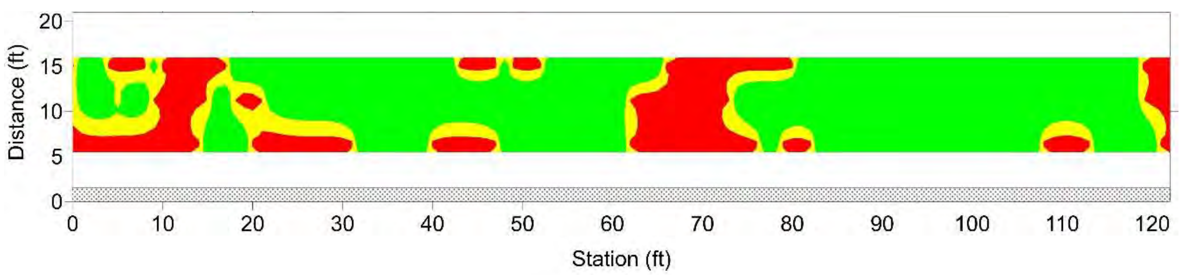


Figure B-15: IE/PV Survey Map for Span 15 Eastbound Fast Lane

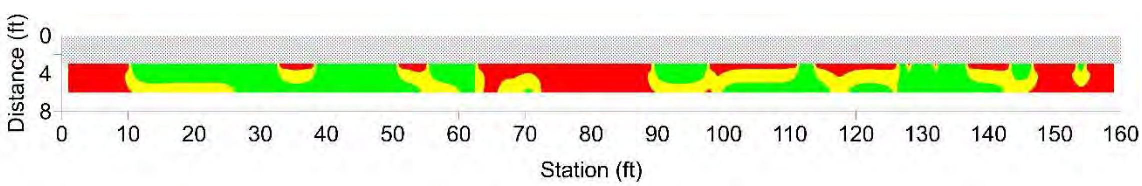


Figure B-16: IE/PV Survey Map for Ramp H

Appendix C
Ground Penetrating Radar Survey Maps

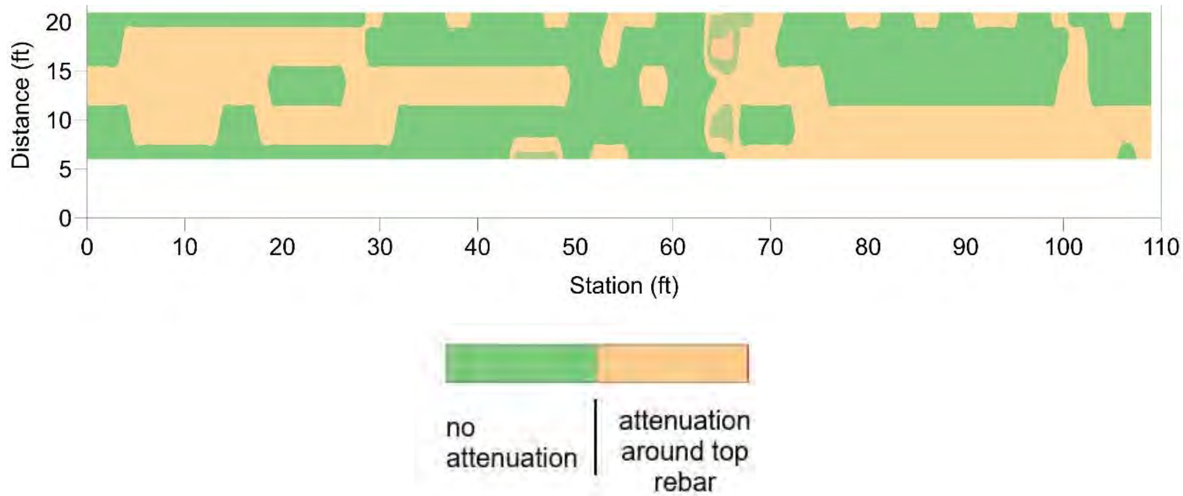


Figure C-1: GPR Survey Map for Span 1 Eastbound Slow Lane

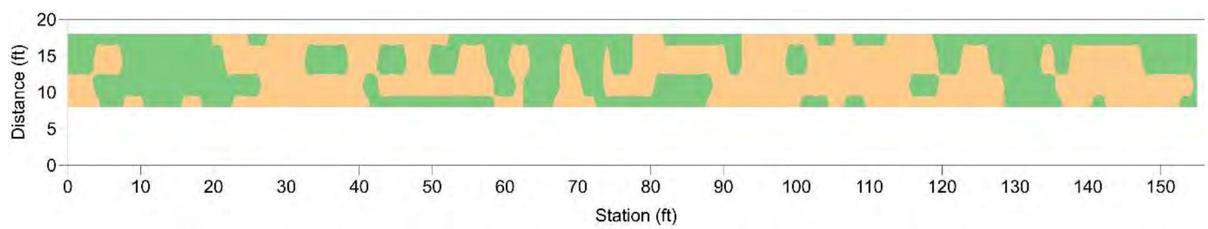


Figure C-2: GPR Survey Map for Span 2 Westbound Fast Lane

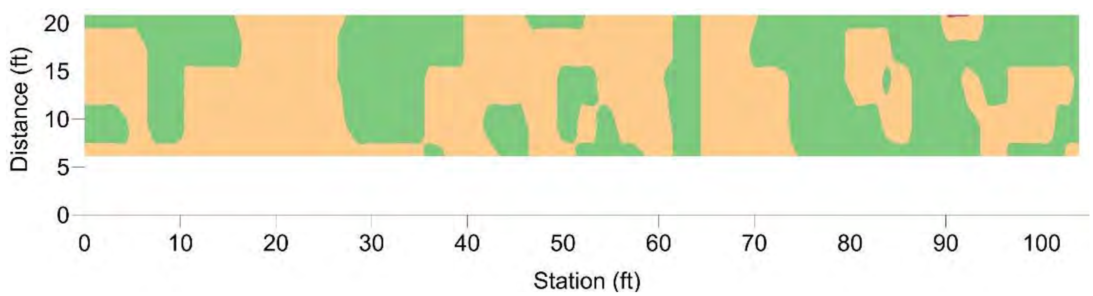


Figure C-3: GPR Survey Map for Span 3 Eastbound Slow Lane

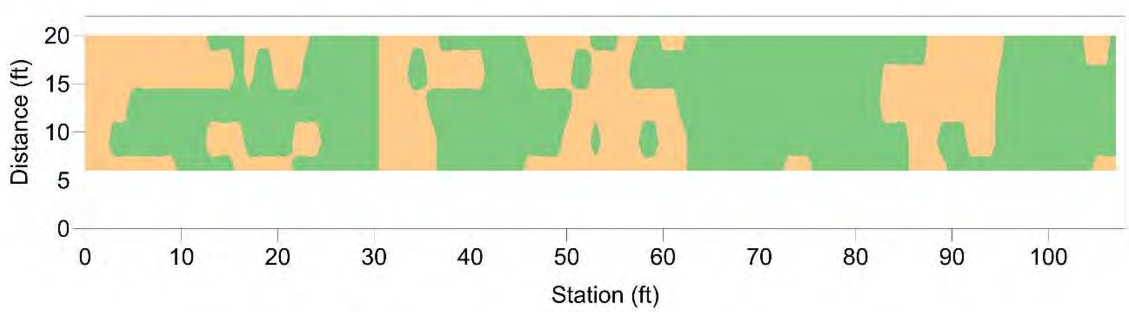


Figure C-4: GPR Survey Map for Span 4 Westbound Slow Lane

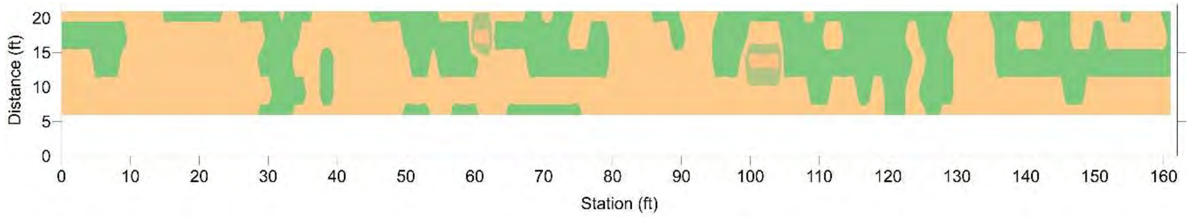


Figure C-5: GPR Survey Map for Span 5 Eastbound Slow Lane

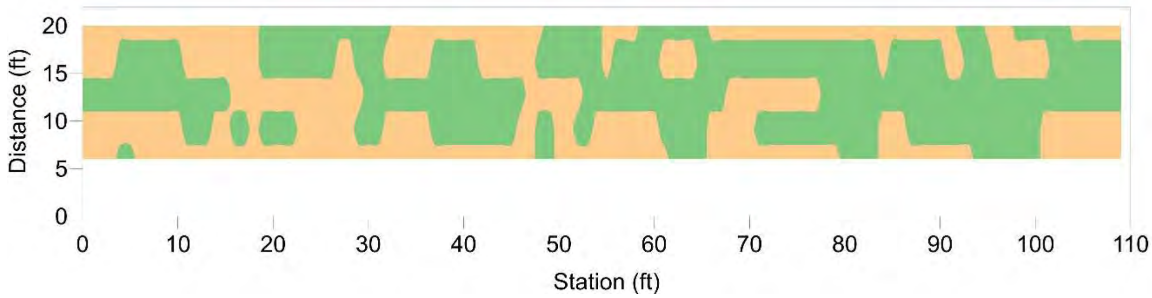


Figure C-6: GPR Survey Map for Span 6 Westbound Slow Lane

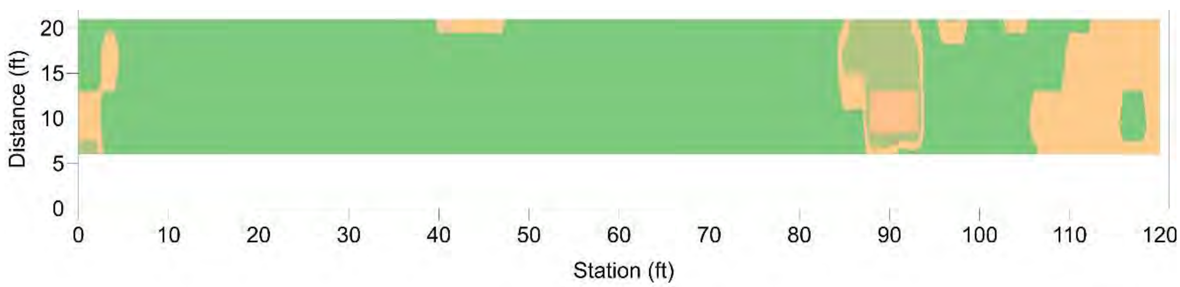


Figure C-7: GPR Survey Map for Span 7 Eastbound Slow Lane

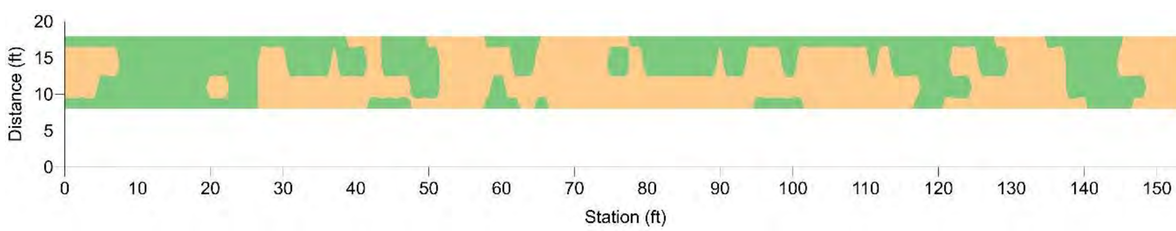


Figure C-8: GPR Survey Map for Span 8 Westbound Fast Lane

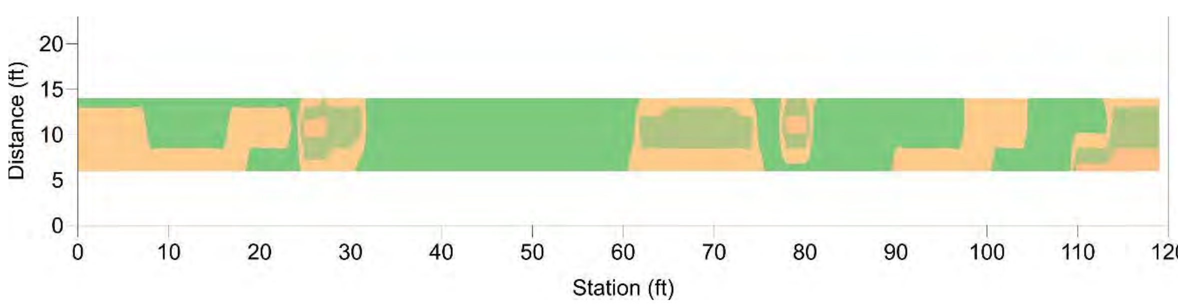


Figure C-9: GPR Survey Map for Span 9 Eastbound Fast Lane

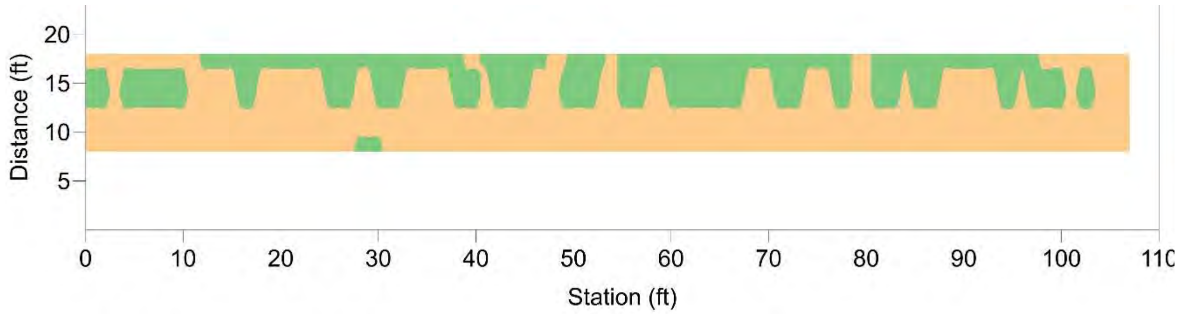


Figure C-10: GPR Survey Map for Span 10 Westbound Fast Lane

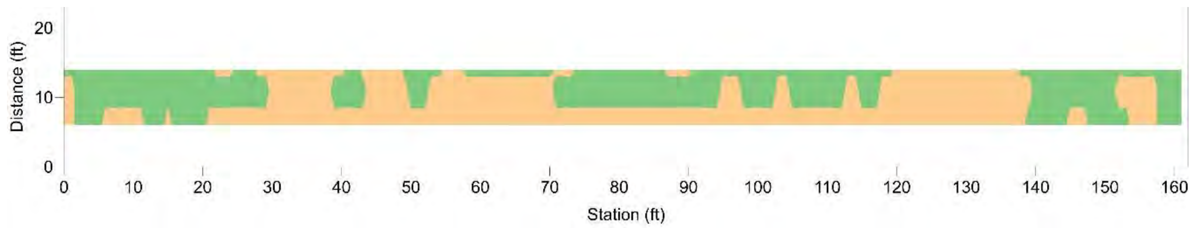


Figure C-11: GPR Survey Map for Span 11 Eastbound Fast Lane

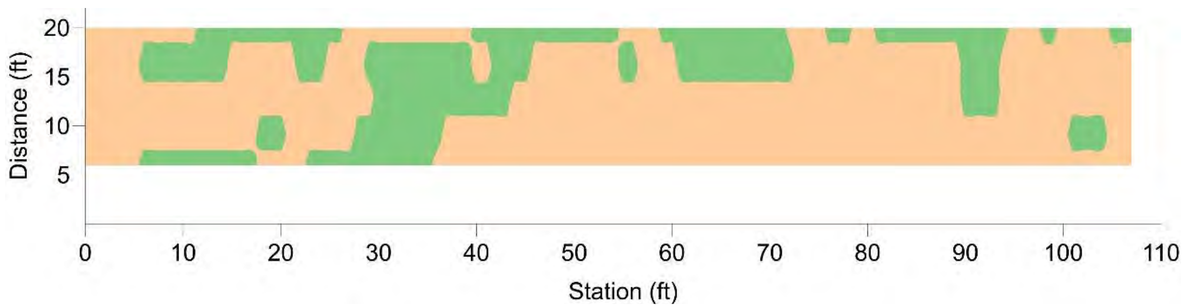


Figure C-12: GPR Survey Map for Span 12 Westbound Slow Lane

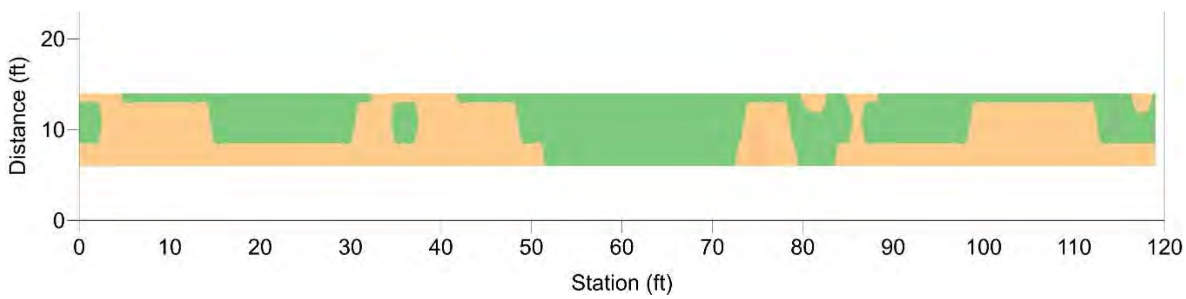


Figure C-13: GPR Survey Map for Span 13 Eastbound Fast Lane

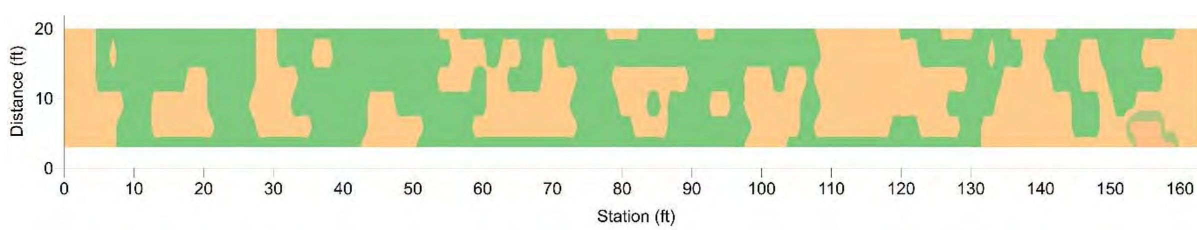


Figure C-14: GPR Survey Map for Span 14 Westbound Slow Lane

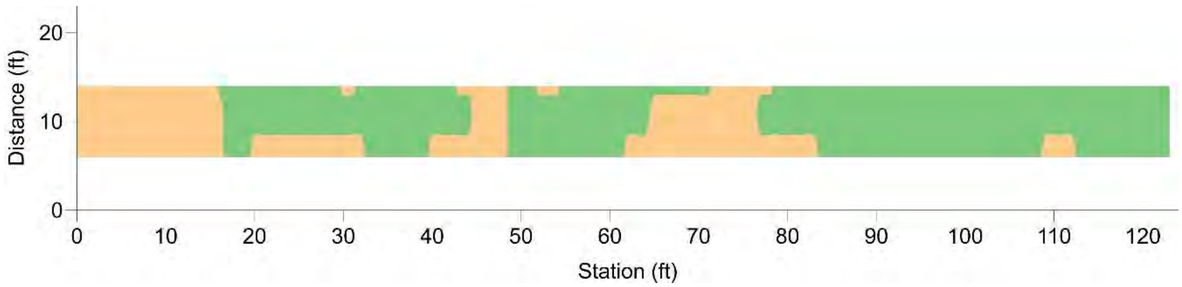


Figure C-15: GPR Survey Map for Span 15 Eastbound Fast Lane

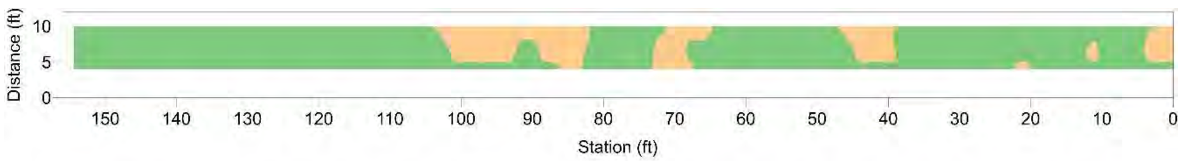


Figure C-16: GPR Survey Map for Ramp H

Appendix D
Corrosion Potential Survey Maps

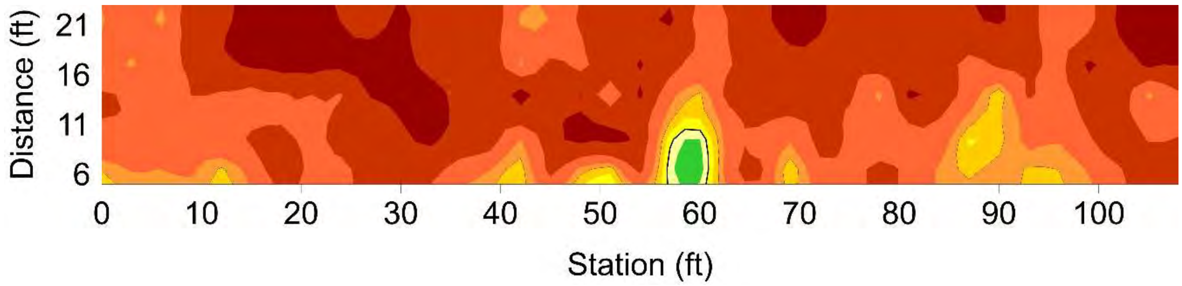


Figure D-1: Corrosion Potential Survey of Span 1 Eastbound Slow Lane

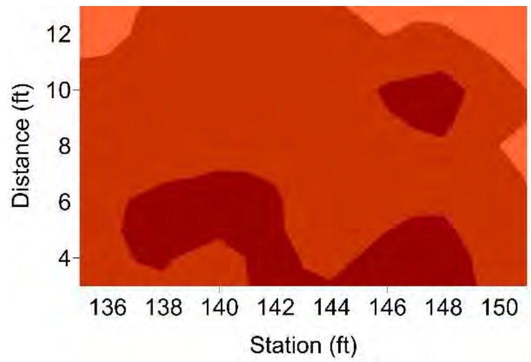


Figure D-2: Corrosion Potential Survey of Span 2 Westbound Fast Lane

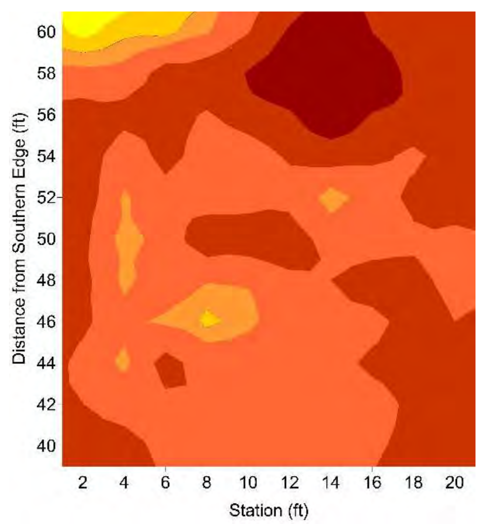
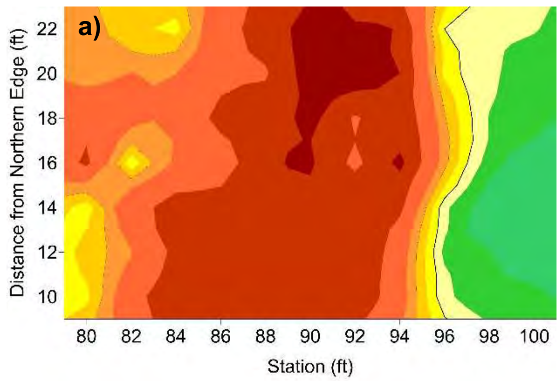


Figure D-3: Corrosion Potential Survey of Span 3 Eastbound Slow Lane



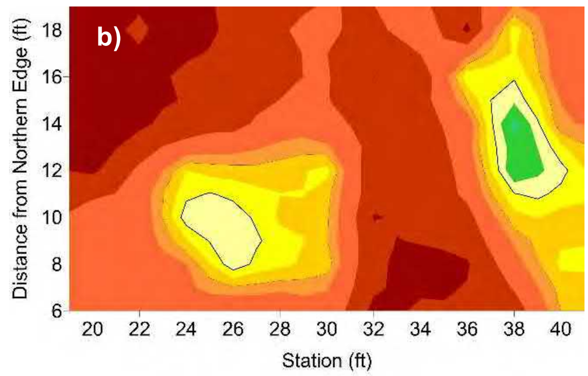


Figure D-4: Corrosion Potential Survey of a) Area1 and b) Area 2 in Span 4 Westbound Slow Lane

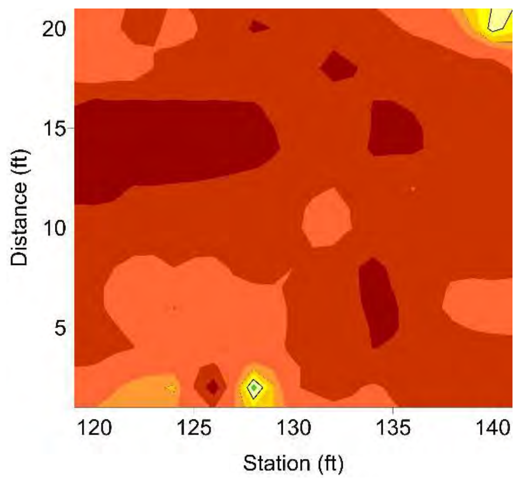


Figure D-5: Corrosion Potential Survey of Span 5 Eastbound Slow Lane

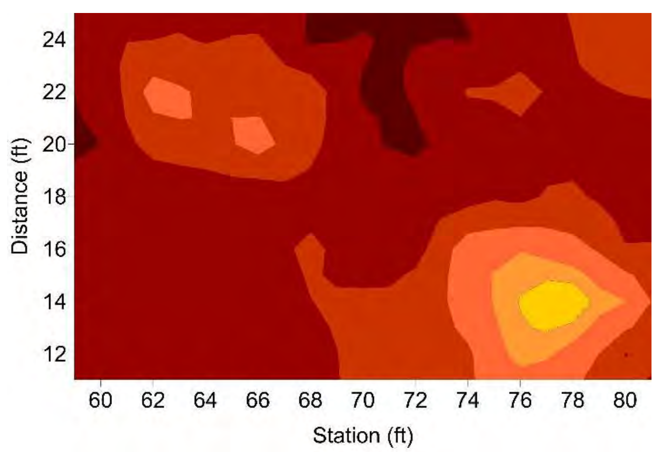


Figure D-6: Corrosion Potential Survey of Span 6 Westbound Slow Lane

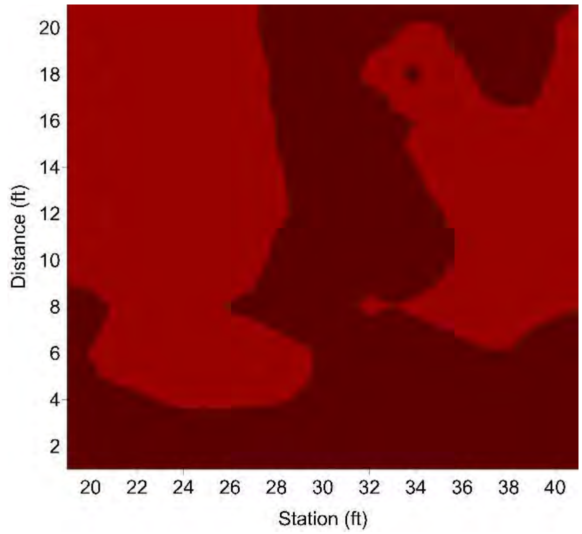


Figure D-7: Corrosion Potential Survey of Span 7 Eastbound Slow Lane

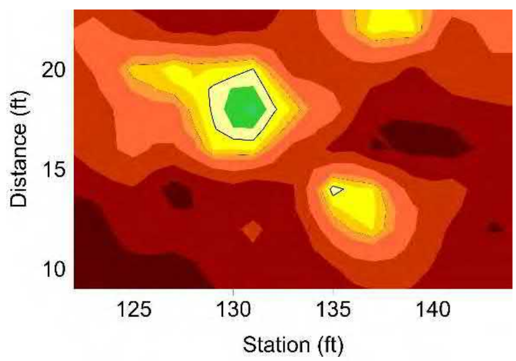


Figure D-8: Corrosion Potential Survey of Span 8 Westbound Fast Lane

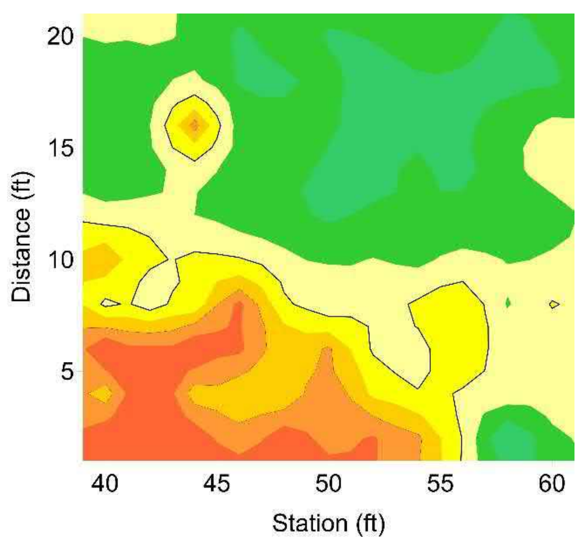


Figure D-9: Corrosion Potential Survey of Span 9 Eastbound Slow Lane

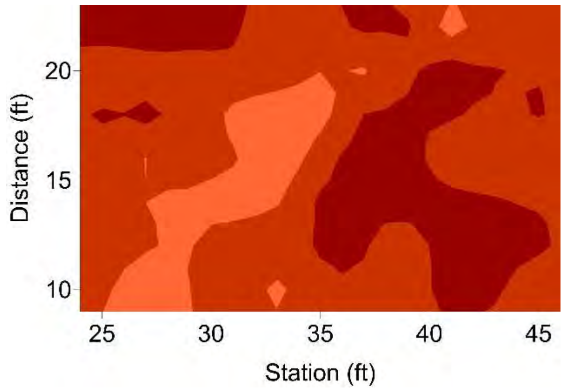


Figure D-10: Corrosion Potential Survey of Span 10 Westbound Fast Lane

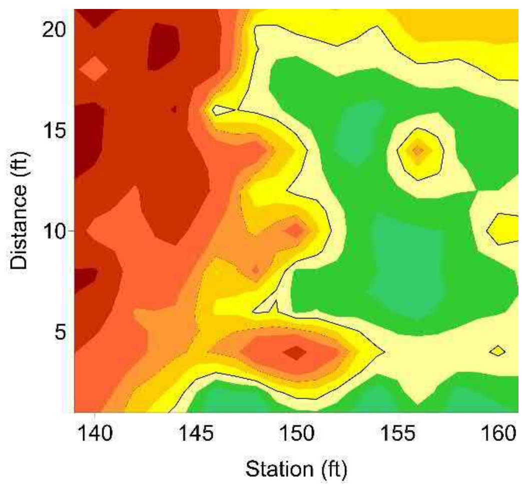


Figure D-11: Corrosion Potential Survey of Span 11 Eastbound Slow Lane

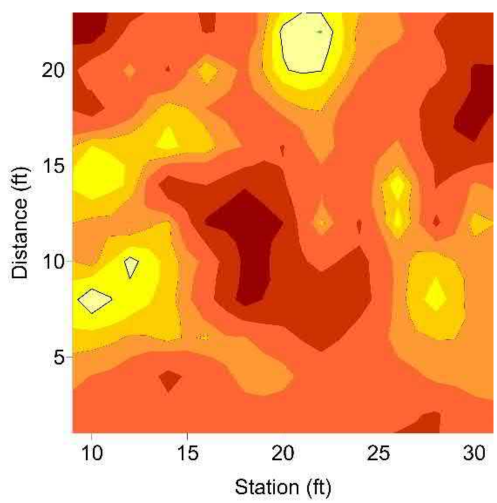


Figure D-12: Corrosion Potential Survey of Span 12 Westbound Slow Lane

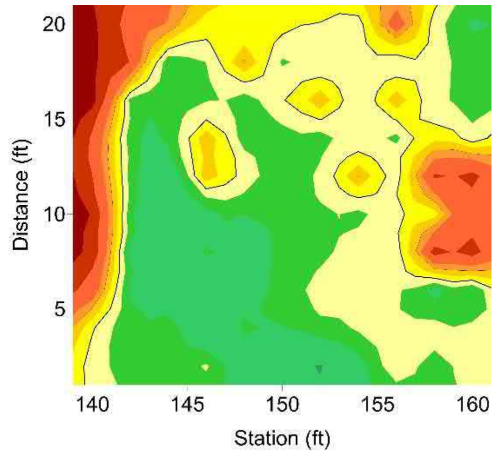


Figure D-13: Corrosion Potential Survey of Span 13 Eastbound Slow Lane

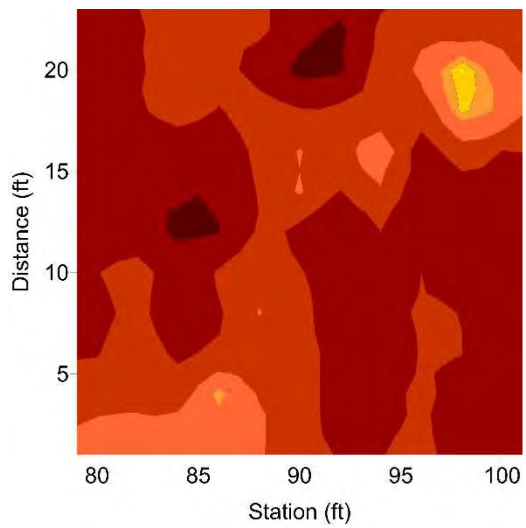


Figure D-14: Corrosion Potential Survey of Span 14 Westbound Slow Lane

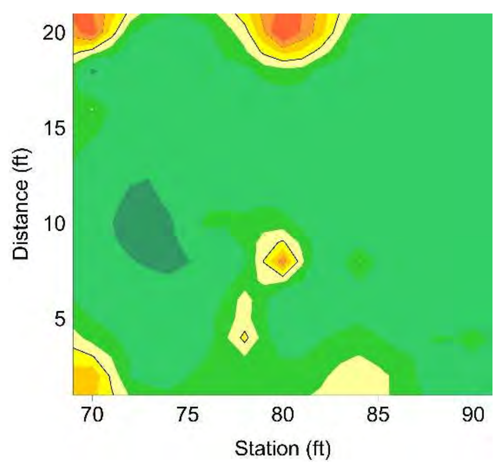


Figure D-15: Corrosion Potential Survey of Span 15 Eastbound Slow Lane

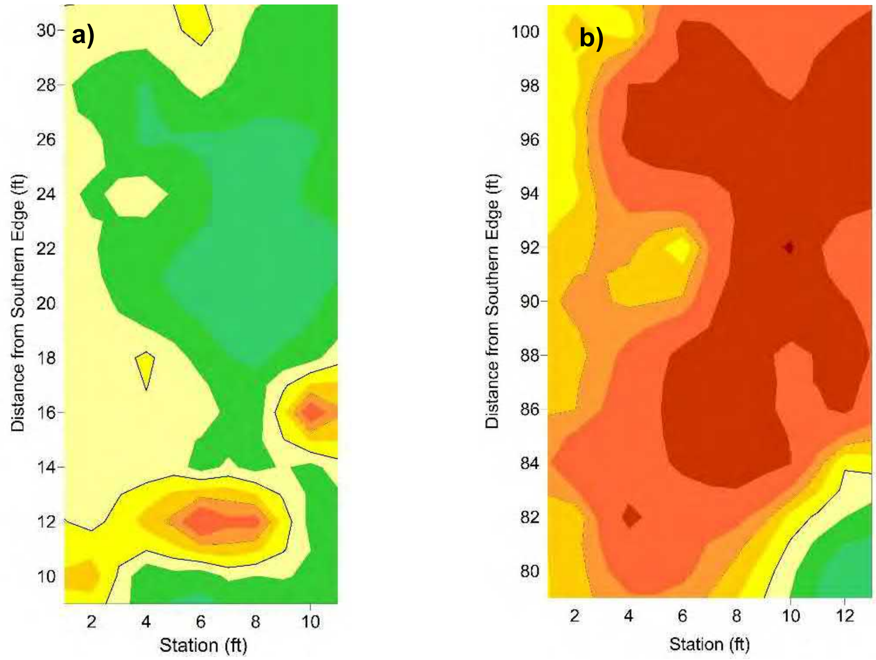


Figure D-16: Corrosion Potential Survey of a) Area1 and b) Area 2 in Ramp H Westbound

D. Deck Core Evaluation and Test Results

Appendix E
Core Photo Log

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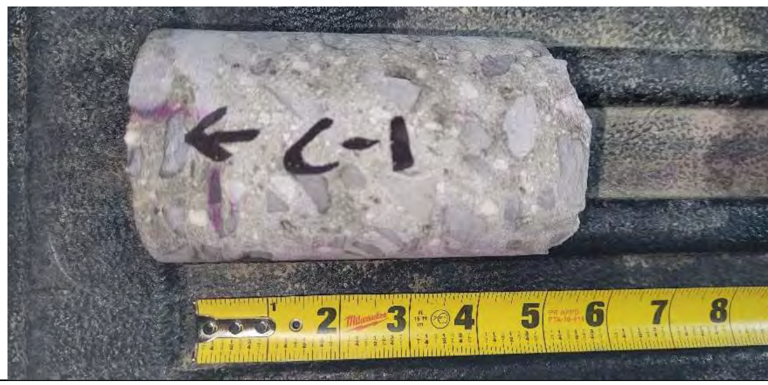
<tr><td colspan="3">
</td></tr>
<tr><td colspan="3">Side B</td></tr>
<tr><td colspan="3">
</td></tr>
<tr><td colspan="3">Side C</td></tr>
<tr><td>Length: 4.75”</td><td>0” Carbonation</td><td>Location:
Eastbound - Slow Lane
West Approach Slab
8’ North from South Curb
27.5’ West of West Abutment</td></tr>
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<tr><td>Top 1</td><td>Bottom 1</td></tr>
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Core 2		
		
Side A with Carbonation Test		
		
Side B		
		
Side C		
Length: 5.5”	0” Carbonation	Location: Eastbound - Slow Lane Span 1 13.5' North from South Curb 59.5' East of West Abutment

Core 2	
	
Top	Bottom

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<tr><td>Length: 4.75”</td><td>0” Carbonation</td><td>Location:
Eastbound - Slow Lane
Span 3
24' North from South Curb
50.5' West of Pier 3</td></tr>
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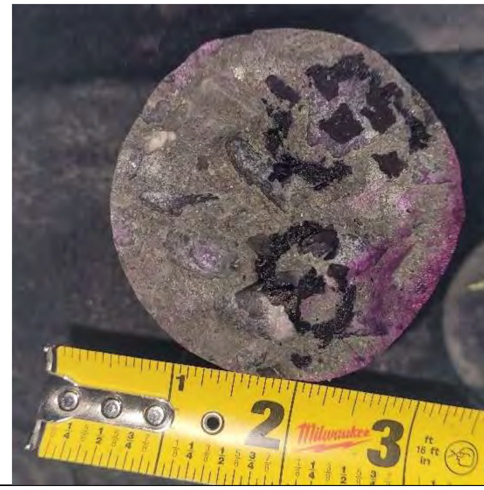
<tr><td></td><td></td></tr>
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<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Side C</td></tr>
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Eastbound - Slow Lane
Span 5
13' North from South Curb
33' West of Pier 5</td></tr>
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Core 4	
	
Top	Bottom

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<tr><td colspan="3">
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<tr><td colspan="3">Side C</td></tr>
<tr><td>Length: 5.75”</td><td>0” Carbonation</td><td>Location:
Eastbound - Slow Lane
Span 7
21.5' North from South Curb
28.5' East of Pier 6</td></tr>
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	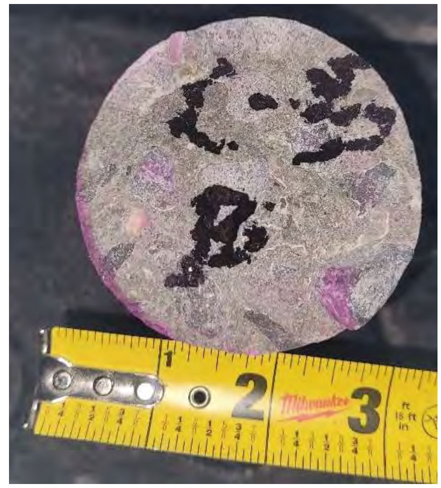
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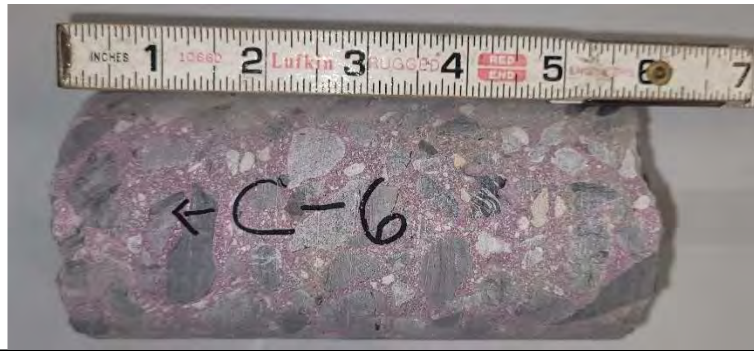
<tr><td colspan="3">
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<tr><td colspan="3">Side A with Carbonation Test</td></tr>
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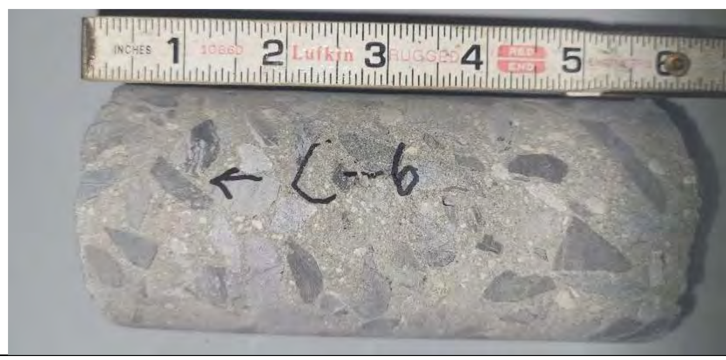
<tr><td colspan="3">
</td></tr>
<tr><td colspan="3">Side C</td></tr>
<tr><td>Length: 6.25”</td><td>0” Carbonation</td><td>Location:
Eastbound – High Speed Lane
Span 9
13.5' South of Center Joint
42' East of Pier 8</td></tr>
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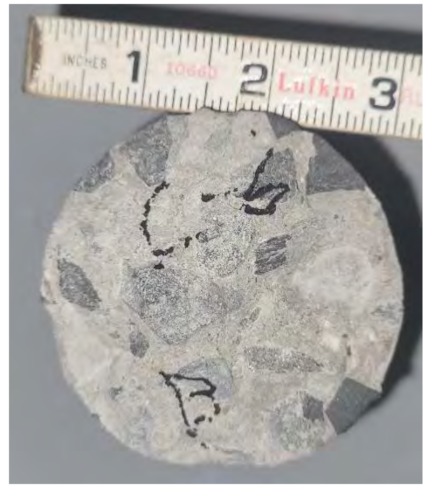
Core 6	
	
Top	Bottom

<table>
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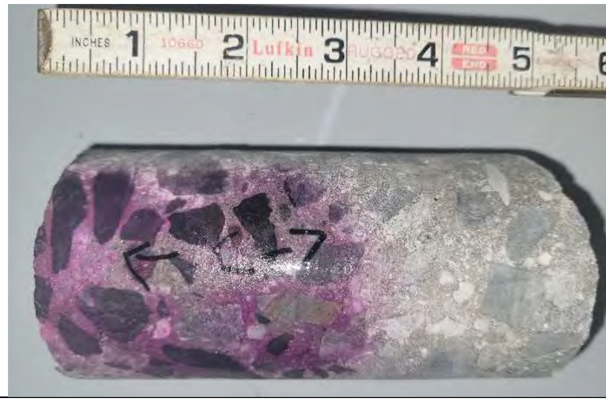
<tr><td colspan="3">
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<tr><td colspan="3">Side A with Carbonation Test</td></tr>
<tr><td colspan="3">
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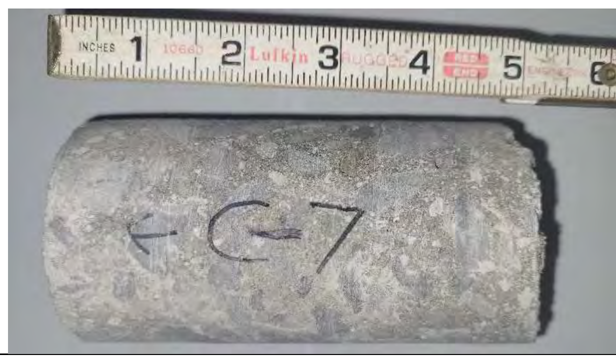
<tr><td colspan="3">Side B</td></tr>
<tr><td colspan="3">
</td></tr>
<tr><td colspan="3">Side C</td></tr>
<tr><td>Length: 5.75”</td><td>0” Carbonation</td><td>Location:
Eastbound – High Speed Lane
Span 11
14.6' South of Center Joint
70.5' East of Pier 10</td></tr>
</table>

Core 7	
	
Top	Bottom

<table>
<tr><th colspan="3">Core 8</th></tr>
<tr><td colspan="3">
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<tr><td colspan="3">Side A with Carbonation Test</td></tr>
<tr><td colspan="3">
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<tr><td colspan="3">Side B</td></tr>
<tr><td colspan="3">
</td></tr>
<tr><td colspan="3">Side C</td></tr>
<tr><td>Length: 6”</td><td>0” Carbonation</td><td>Location:
Eastbound – High Speed Lane
Span 13
15' South of Center Joint
14.75' East of Pier 12</td></tr>
</table>

Core 8	
	
Top	Bottom

Core 9

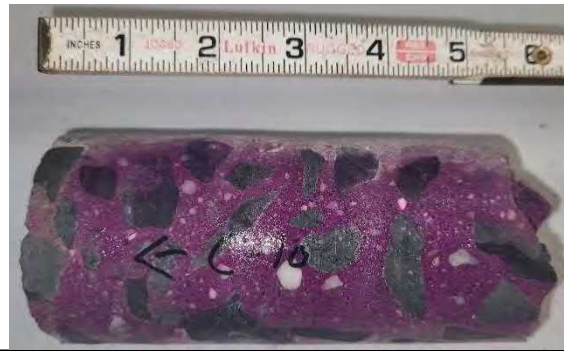
Side A with Carbonation Test

Side B

Side C

Length: 6”	0” Carbonation	Location: Eastbound – High Speed Lane Span 15 7.8' South of Center Joint 53.5' East of Pier 41

Core 9	
	
Top	Bottom

Core 10		
		
Side A with Carbonation Test		
		
Side B		
		
Side C		
Length: 6.25”	0” Carbonation	Location: Eastbound – High Speed Lane East Approach 12.5' South of Center Joint 11' East of East Abutment

Core 10	
	
Top	Bottom

<table>
<tr><td colspan="3">Core 11</td></tr>
<tr><td colspan="3">
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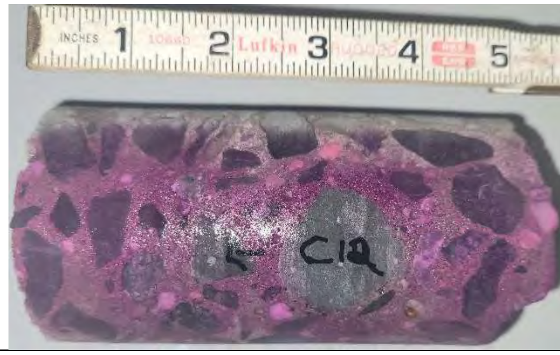
<tr><td colspan="3">Side A with Carbonation Test</td></tr>
<tr><td colspan="3">
</td></tr>
<tr><td colspan="3">Side B</td></tr>
<tr><td colspan="3">
</td></tr>
<tr><td colspan="3">Side C</td></tr>
<tr><td>Length: 5.5”</td><td>0” Carbonation</td><td>Location:
Westbound – Slow Lane
Span 12
13.3' South of North Curb
30.6' East of Pier 11</td></tr>
</table>

Core 11	
	
Top	Bottom

Core 12



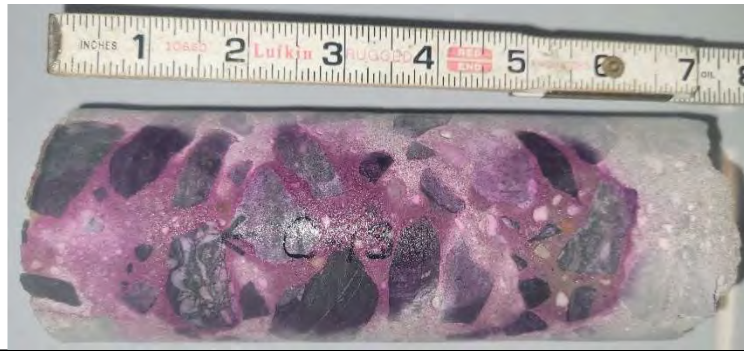
Side A with Carbonation Test

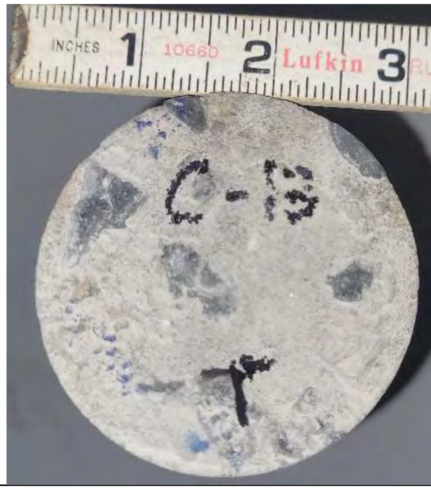
Side B

Side C

Length: 6”	0” Carbonation	Location: Westbound – Slow Lane Span 14 7.1' South of North Curb 30.1' East of Pier 13

Core 12	
	
Top	Bottom

Core 13		
		
Side A with Carbonation Test		
		
Side B		
		
Side C		
Length: 7.25”	0” Carbonation	Location: Ramp – Left Lane H Approach 10.3' North of South Curb 7.3' East of East Abutment

Core 13	
	
Top	Bottom

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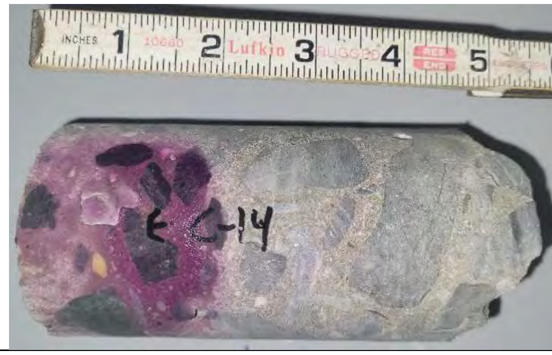
<tr><td colspan="3">
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<tr><td colspan="3">Side A with Carbonation Test</td></tr>
<tr><td colspan="3">
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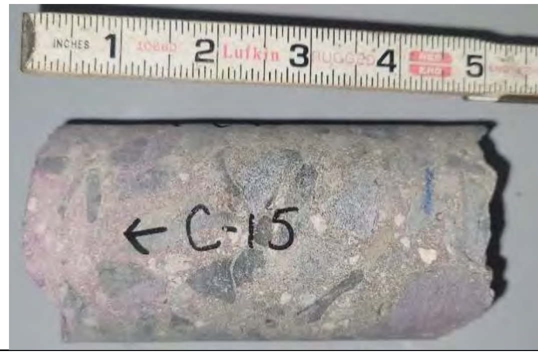
<tr><td colspan="3">Side B</td></tr>
<tr><td colspan="3">
</td></tr>
<tr><td colspan="3">Side C</td></tr>
<tr><td>Length: 5.75”</td><td>0” Carbonation</td><td>Location:
Ramp – Left Lane
H Approach
11.6' North of South Curb
28' East of East Abutment</td></tr>
</table>

Core 14	
	
Top	Bottom

Core 15

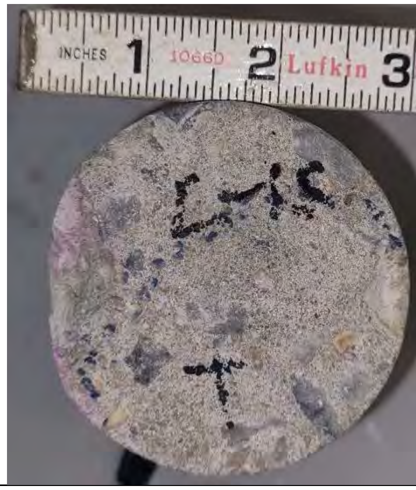


Side A with Carbonation Test

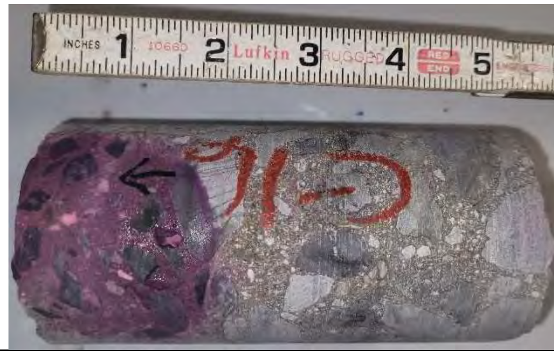
Side B

Side C

Length: 5.5”	0” Carbonation	Location: Ramp – Left Lane Ramp H 6.6' North of South Curb 59' West of East Abutment

Core 15	
	
Top	Bottom

Core 16



Side A with Carbonation Test

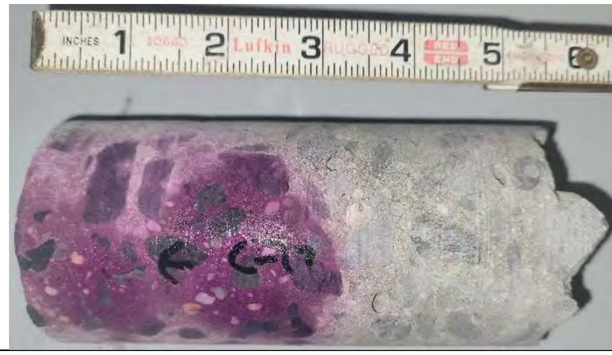
Side B

Side C

Length: 5.75”	0” Carbonation	Location: Westbound – Slow Lane Span 6 10.75' South of North Curb 9.1' East of Pier 5

Core 16	
	
Top	Bottom

Core 17



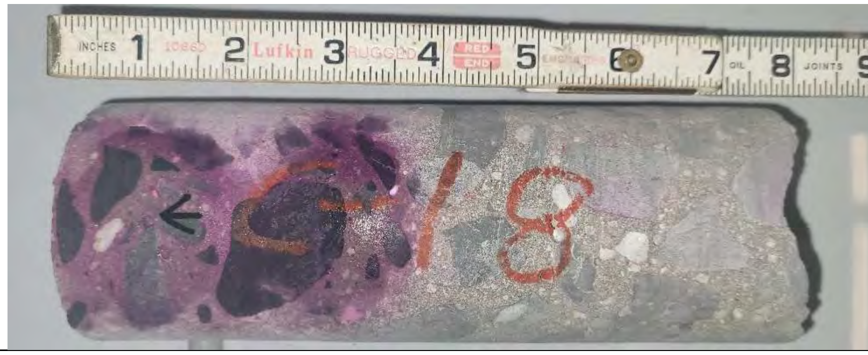
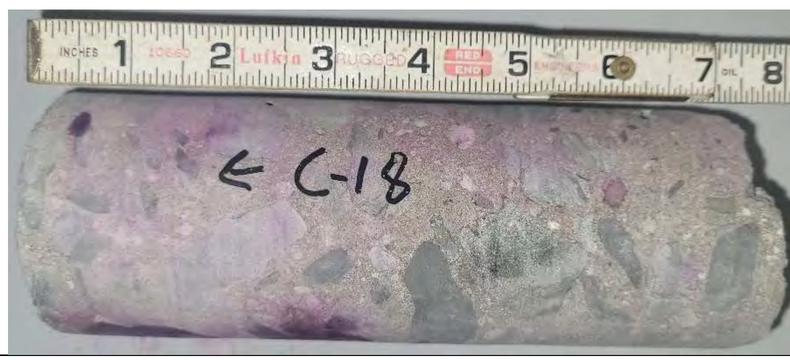
Side A with Carbonation Test

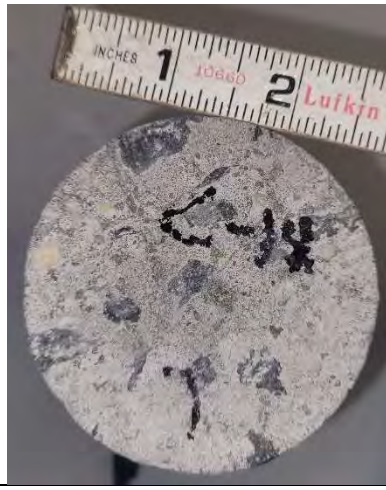
Side B

Side C

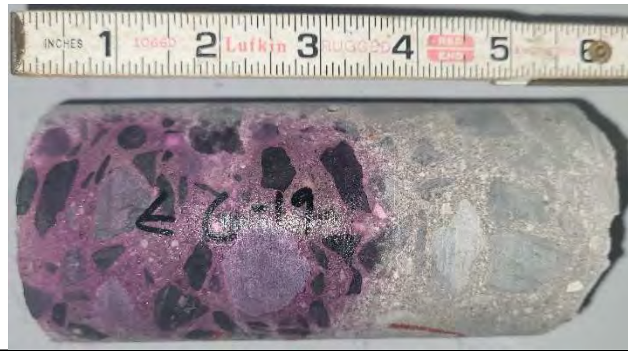
Length: 6”	0” Carbonation	Location: Westbound – Slow Lane Span 4 12.5' South of North Curb 44.9' East of Pier 3

Core 17	
	
Top	Bottom

Core 18		
		
Side A with Carbonation Test		
		
Side B		
		
Side C		
Length: 7.75”	0” Carbonation	Location: Westbound – Slow Lane West Approach 12.5' South of North Curb 18.8' West of West Abutment

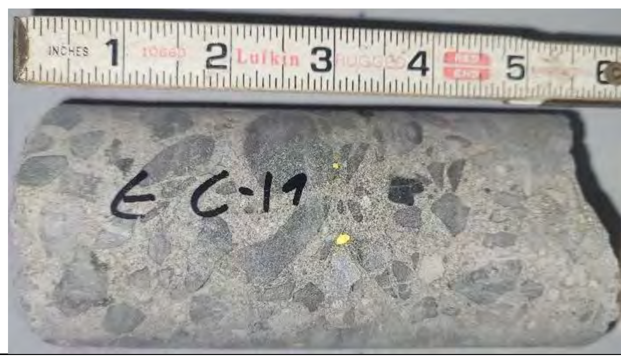
Core 18	
	
Top	Bottom

Core 19



Side A with Carbonation Test

Side B



Side C

Length: 5.75”	0” Carbonation	Location: Westbound – Slow Lane Span 2 18.1' North of Center Joint 15.6' East of Pier 1

<table>
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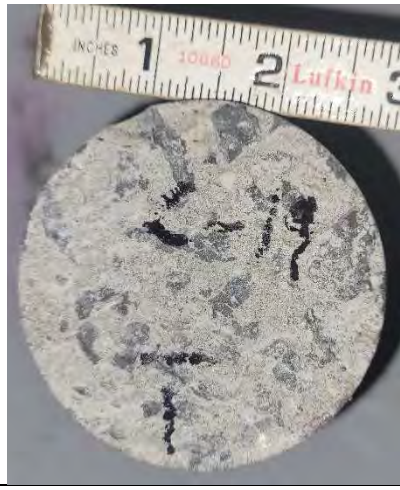
<tr><td>
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<tr><td>Top</td><td>Bottom</td></tr>
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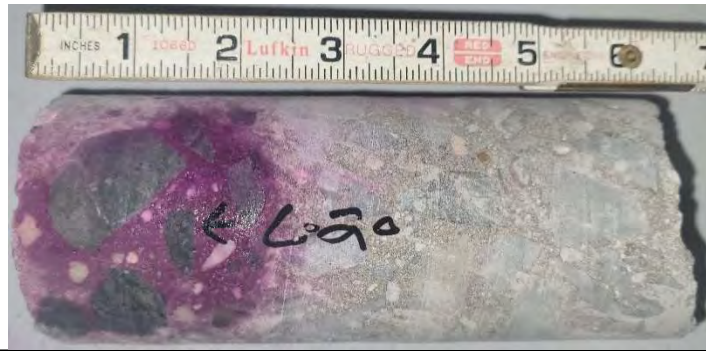
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Side A with Carbonation Test</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Side B</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">Side C</td></tr>
<tr><td>Length: 6.75”</td><td>0” Carbonation</td><td>Location:
Westbound – High Speed Lane
East Approach
16.3' North of Center Joint
12' East of East Abutment</td></tr>
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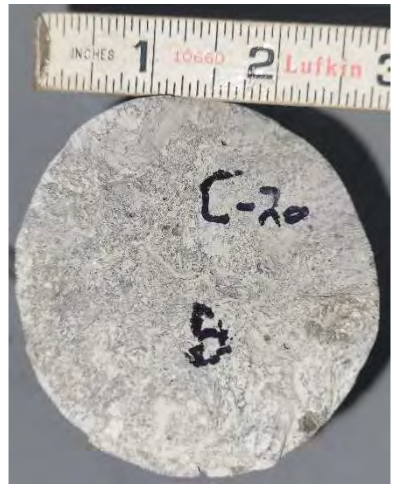
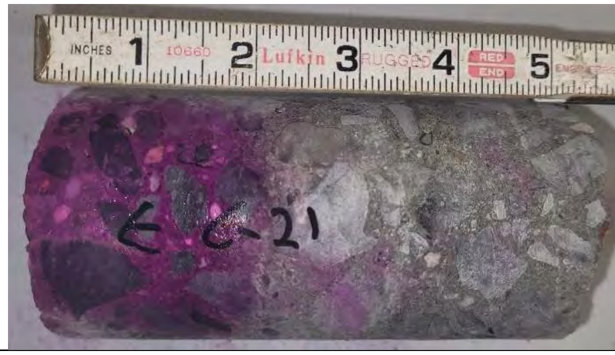
Core 20	
	
Top	Bottom

Core 21



Side A with Carbonation Test

Side B

Side C

Length: 5.75”	0” Carbonation	Location: Westbound – High Speed Lane Span 10 17.25' North of Center Joint 57.1' West of Pier 10

<table>
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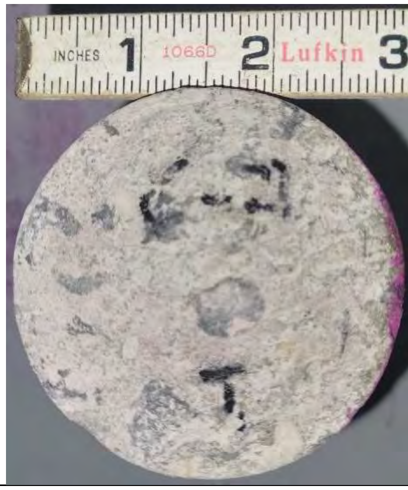
<tr><td>
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<tr><td>Top</td><td>Bottom</td></tr>
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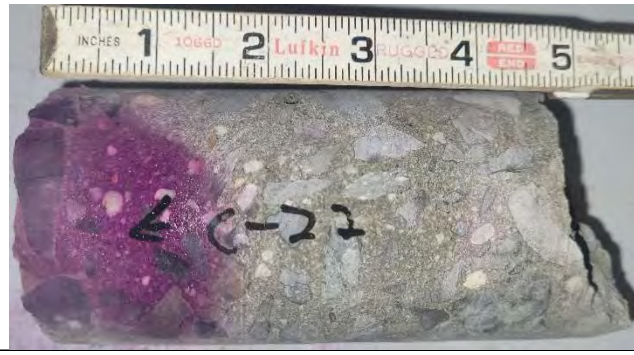
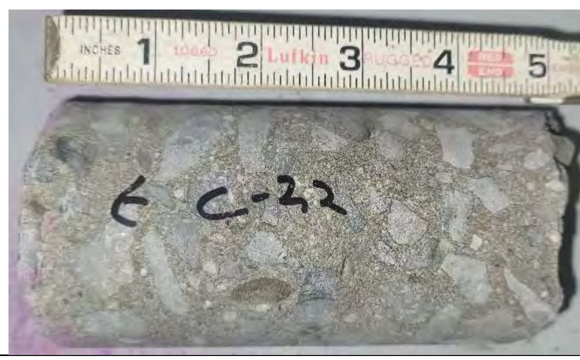
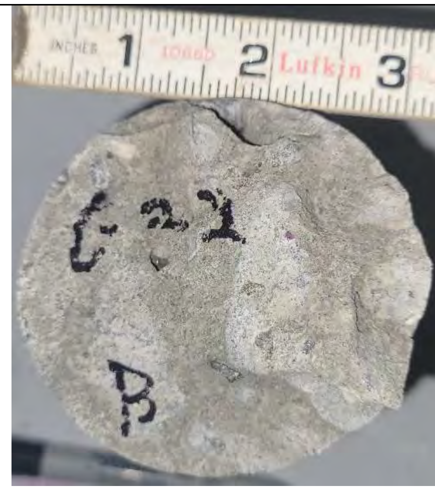
Core 22		
		
Side A with Carbonation Test		
		
Side B		
		
Side C		
Length: 5.75”	0” Carbonation	Location: Westbound – High Speed Lane Span 8 16.9' North of Center Joint 30.5' East of Pier 7

Core 22	
	
Top	Bottom

Appendix F
Petrographic Analysis Report

A Twining Company

2800 Wilderness Place, Suite A
Boulder, CO 80301
T: 303.938.0166
www.drpcinc.com

Petrographic Investigation of Concrete Cores from the Grand Central Parkway Deck Rehabilitation located in Queens County, New York

Prepared for

James Roy
NDT Corporation
Sterling, Massachusetts

Prepared by

Meredith Strow
Report No. 217701.d
8 October 2021

EXECUTIVE SUMMARY

Mr. James Roy of NDT Corporation (**NDT**) located in Sterling, Massachusetts requested DRP, a Twining Company (**DRP**) to perform petrographic examination per ASTM C856 on five concrete cores extracted vertically from the Grand Central Parkway bridge deck located in Queens County, New York. The bridge deck exhibits multiple patch repairs and delamination in the top ~2 in. of the original concrete. The submitted cores represent location where the original concrete is most sound and is not delaminated. The purpose of the investigation is to evaluate the composition and quality of the concrete represented by the submitted cores and to determine the presence of any deleterious mechanisms in the concrete.

Based on findings from the scope of work, the concrete appears to be of good quality and is in good condition excluding significantly deteriorated concrete top surfaces. All five cores exhibit minor cracks and/or microcracks in the top portion of the concrete. Minor alkali-silica reaction (ASR) is present in Core #14 and Core #21. Each of these features is described in detail below.

1) *Deteriorated top surfaces*. All fives cores exhibit a deteriorated top surface that exhibits no original surface and shows coarse aggregate particles exposed in high relief.

2) *Cracks and microcracks*. Core #14 and Core #21 exhibit sub-vertical drying shrinkage cracks and microcracks that cut from the top surface to depths of 9-50 mm (⅜-2 in.). All five cores contain fairly shallow sub-vertical to diagonal microcracks that cut from the top surface to depths of 1-5 mm (40-200 mil). These microcracks are consistent with wear and/or scaling. Salt scaling deterioration typically manifests as these types of microcracks in concrete exposed to deicer salts.

3) *Alkali-silica reaction (ASR)*. Core #14 and Core #21 exhibit ASR with no significant damage. In both cores, the severity of ASR is rated *minor* following a rating scheme developed by DRP and assessed to show *Stage IV* ASR using a rating scheme developed by Katayama (2020). No evidence of ASR is observed in Core #5, Core #9 or Core #19.

Acid-soluble chloride analysis results were provided by **NDT** and show elevated chloride content at the surface of companion cores. Chloride content significantly decreases with depth in the concrete suggesting the chloride is external to the concrete such as by deicer salts. Sub-vertical to diagonal microcracks in the top 1-5 mm of the submitted cores is consistent with salt scaling due to exposure to deicer salts.

Other than minor ASR and salt scaling, no evidence of other deterioration mechanisms (such as freeze-thaw damage, chemical attack, etc.) is observed.

The concrete composition is similar in all five cores. The concrete consists of crushed limestone coarse aggregate with a 19 mm (¾ in.) nominal top size and a siliceous natural sand bound in an air-entrained portland cement paste. No supplementary cementitious materials are observed. The water-cement ratio (w/c) is estimated at 0.40 ± 0.05 in all five cores. The air content is estimated at 5-7% among the cores. The depth of carbonation is generally ~1 mm (40 mil) from the top surface with locally deeper carbonation along sub-vertical cracks and microcracks.

1.0 INTRODUCTION

Mr. James Roy of NDT Corporation (**NDT**) located in Sterling, Massachusetts requested DRP, a Twining Company (**DRP**) to perform petrographic examination per ASTM C856 on five concrete cores extracted vertically from the Grand Central Parkway bridge deck located in Queens County, New York. The bridge deck exhibits multiple patch repairs and delamination ins the top ~2 in. Of the original concrete. The submitted cores represent location where the original concrete is most sound and is not delaminated. The purpose of the investigation is to evaluate the composition and quality of the concrete represented by the submitted cores and to determine the presence of any deleterious mechanisms in the concrete.

On 15 September 2021 **DRP** received five (5) cores from **NDT** labelled Cores #5, #9, #14, #19 and #21. The cores were assigned **DRP** sample numbers 25YD11432-25YD11436, respectively. The concrete is reportedly from the ~1970's and no mix design information is available. **Table 1.1** summarizes core IDs and coring locations. Mr. James Roy and Mr. Ben Armitage (**NDT**) provided job site photographs, a coring location map, compressive strength results of companion cores (~3500-4000 psi range), and chloride analysis testing results of companion cores (summarized in **Table 1.2**). Work authorization was provided on 23 September 2021.

Table 1.1 Summary of Core Information

DRP Sample No.	Client ID	Coring Location	Level of Testing
25YD11432	Core #5	Eastbound Span 7	Level I Petrographic Examination (ASTM C856)
25YD11433	Core #9	Eastbound Span 15	Level I Petrographic Examination (ASTM C856)
25YD11434	Core #14	Ramp H Approach	Level II Petrographic Examination (ASTM C856)
25YD11435	Core #19	Westbound Span 2	Level I Petrographic Examination (ASTM C856)
25YD11436	Core #21	Westbound Span 10	Level I Petrographic Examination (ASTM C856)

Table 1.2 Summary of Chloride Testing Results

Client ID	Chloride Content (ppm)				
	0 - ½ in.	½ - 1 in.	1 ½ - 2 in.	2 ½ - 3 in.	3 ½ - 4 in.
Core 2	4364	4835	2094	1079	369
Core 8	2526	2597	916	324	304
Core 10	2301	4131	2295	1377	955
Core 13	2454	5021	1683	562	246
Core 17	3157	1964	527	294	251
Core 18	3405	2948	1136	449	319
Core 22	2280	2802	1491	580	197

2.0 SCOPE OF WORK

The testing involved petrographic examination according to ASTM C856 [**1**]. This report summarizes the main findings of this investigation. *Appendices A-E* contain the notes, photographs and micrographs from the petrographic examinations of the cores. *Appendix F* summarizes the procedures used to perform this scope of work.

1 *Standard Practice for Petrographic Examination of Hardened Concrete.* Annual Book of ASTM Standards, Vol. 4.02., ASTM C856-20.

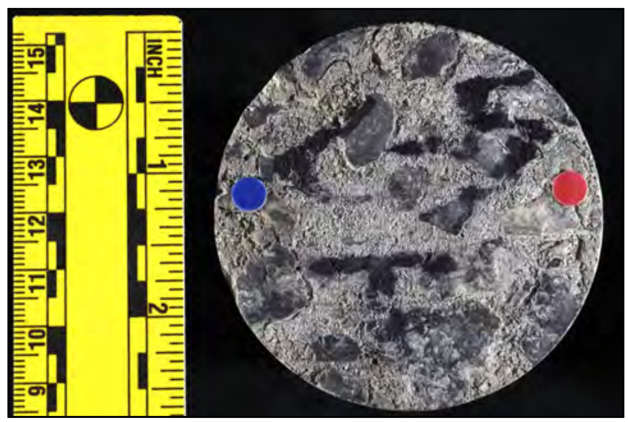
3.0 FINDINGS

3.1 *Orientation, Dimensions & As-Received Condition*

All five cores are vertical in orientation, and measure ~70 mm (2 ¾ in.) in diameter and 140-150 mm (5 ½ - 5 ⅞ in.) in length. All fives cores exhibit a worn or deteriorated top surface that exhibits exposed aggregate particles. Core #5 exhibits exposed coarse aggregate particles and the other four cores show both coarse and fine aggregate particles exposed. The bottom surface of all five cores is a fractured surface in which the fracture passes mostly around coarse aggregate particles; all fives cores represent a partial slab thickness. None of the cores contain reinforcement (steel bar, wire mesh, fibers, etc.).

Figure 1 shows photographs of the cores in as received condition.
Figure 2 shows photographs highlighting detail of the core top surfaces.
Figure 3 shows photographs of the polished surface prepared from each core.


(a)


(b)


(c)

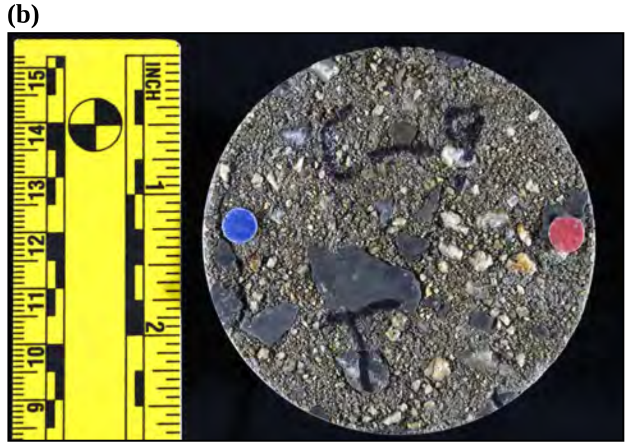
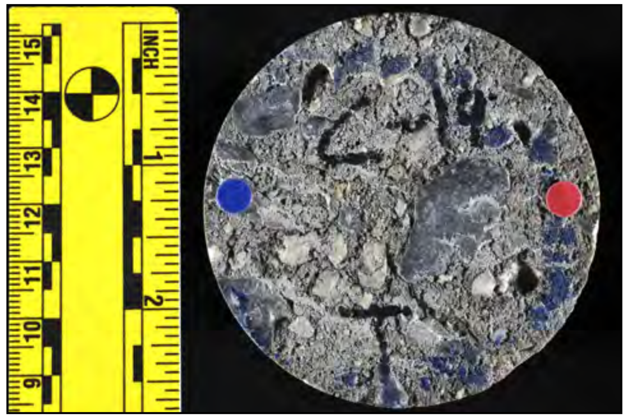
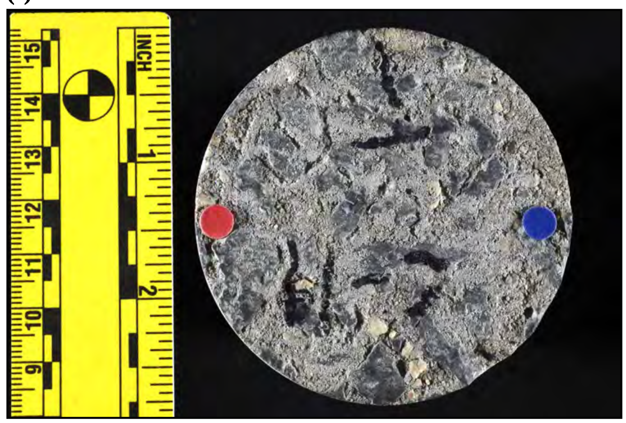

(d)

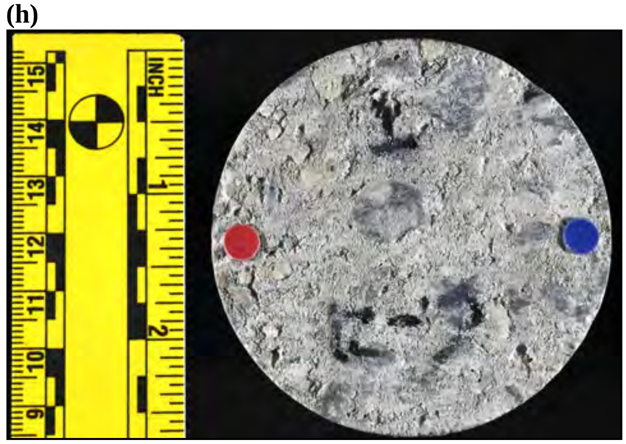
Figure 1. Images showing cores in as received condition. Photographs showing (a) oblique view of core top and side of surface and (b) view of top surface of Core #5. Photographs showing (c) oblique view of core top and side of surface and (d) view of top surface of Core #9. Red and blue dots indicate orientation of saw cuts used to prepare the samples. The yellow scale is ~150 mm (6 in.) long; small and large divisions on the yellow scale are in centimeters and inches, respectively.



(e) (f)

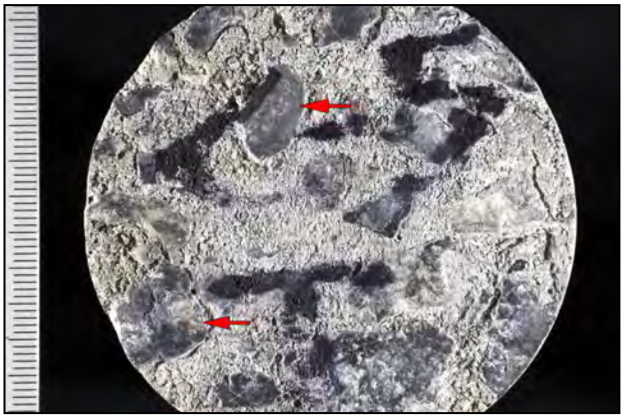
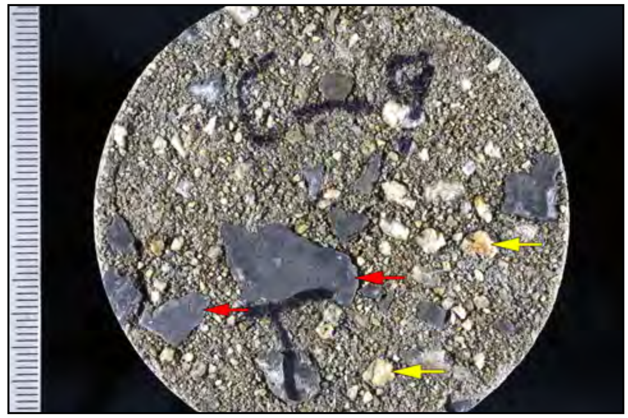


(g) (h)

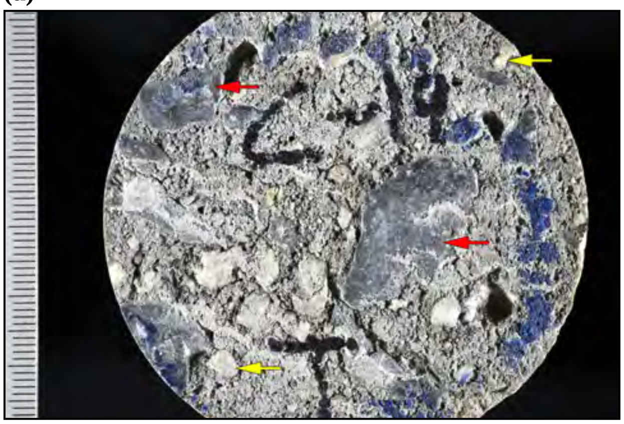


(i) (j)

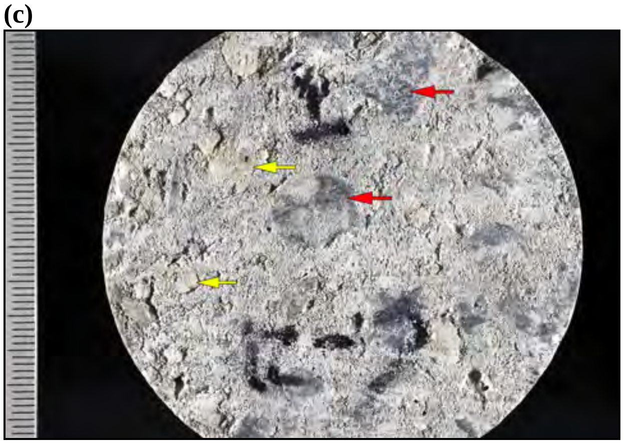
Figure 1 (cont'd). Images showing cores in as received condition. Photographs showing (e) oblique view of core top and side of surface and (f) view of top surface of Core #14. Photographs showing (g) oblique view of core top and side of surface and (h) view of top surface of Core #19. Photographs showing (i) oblique view of core top and side of surface and (j) view of top surface of Core #21. Red and blue dots indicate orientation of saw cuts used to prepare the samples. The yellow scale is ~150 mm (6 in.) long; small and large divisions on the yellow scales are in centimeters and inches, respectively.

(a) **(b)**




(c) **(d)**



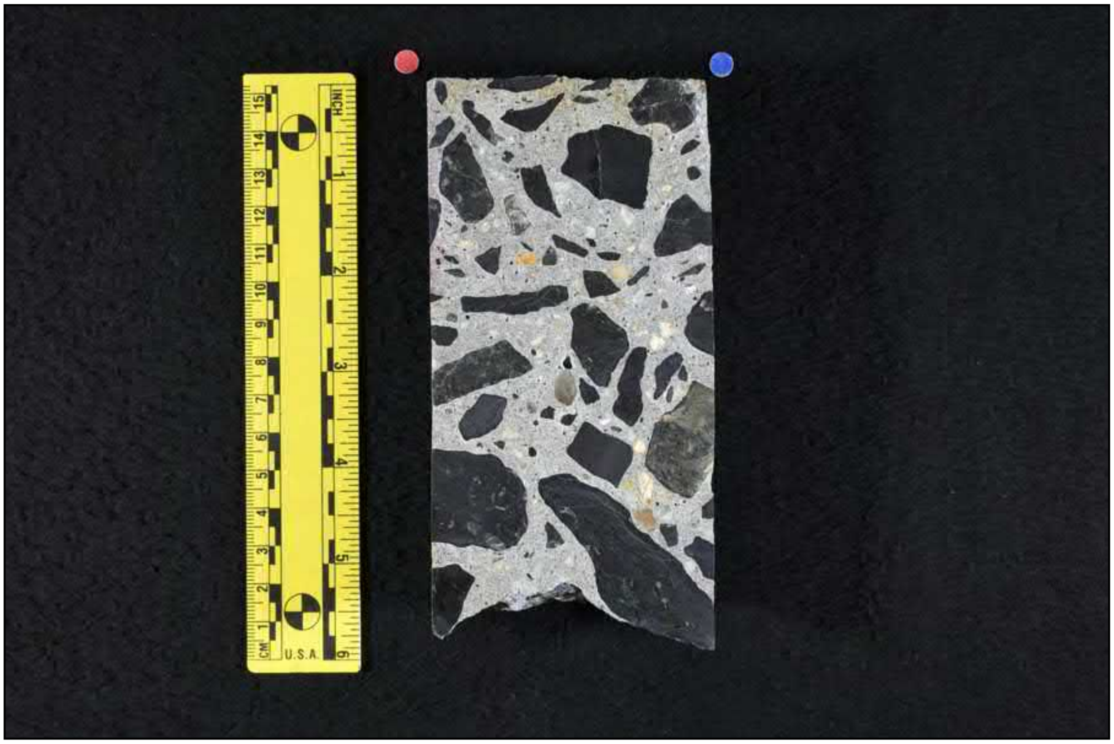
(e)

Figure 2. Images showing additional detail of the core top surfaces. Photographs showing exposed coarse aggregate particles (red arrows) and exposed fine aggregate particles (yellow arrows) on the top surface of (a) Core #5, (b) Core #9, (c) Core #14, (d) Core #19 and (e) Core #21. The scale in each image shows millimeter increments.

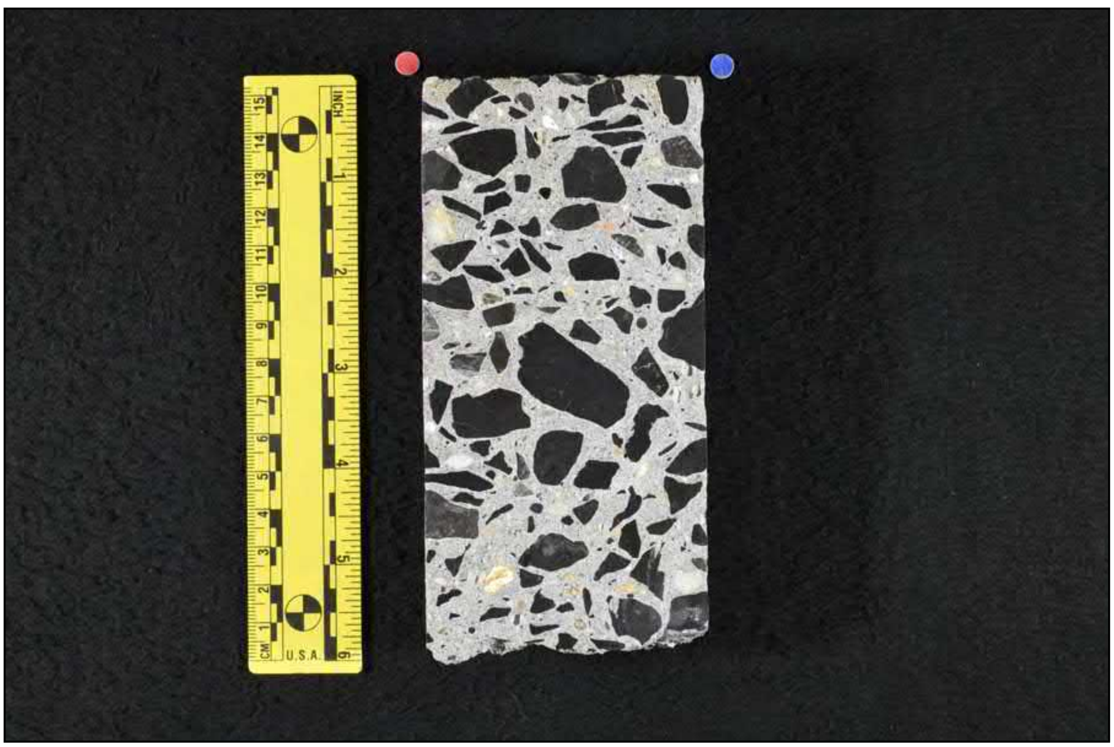
(a)

(b)

Figure 3. Photographs showing the polished surface of (a) Core #5 and (b) Core #5. Red and blue dots indicate orientation of saw cuts used to prepare the samples. The yellow scale is ~150 mm (6 in.) long; small and large divisions on the yellow scales are in centimeters and inches, respectively.



(c)



(d)

Figure 3 (cont'd). Photographs showing the polished surface of (c) Core #14 and (d) Core #19. Red and blue dots indicate orientation of saw cuts used to prepare the samples. The yellow scale is ~150 mm (6 in.) long; small and large divisions on the yellow scales are in centimeters and inches, respectively.

(c)

Figure 3 (cont'd). Photographs showing the polished surface of (e) Core #21. Red and blue dots indicate orientation of saw cuts used to prepare the samples. The yellow scale is ~150 mm (6 in.) long; small and large divisions on the yellow scales are in centimeters and inches, respectively.

3.2 *Sub-vertical Cracks and Sub-vertical to Diagonal Microcracks*

Core #14 exhibits two ~150 µm (6 mil) wide sub-vertical cracks that cut from the top surface to depths of 12 mm (½ in.) and 50 mm (2 in.) into the concrete. No other cores exhibit cracks. Core #21 exhibits similar ~25-100 µm (1-4 mil) wide sub-vertical microcracks that cut sub-vertically from the top surface to depths of 9 mm (⅜ in.) into the concrete. These cracks and microcracks are linear and narrow with depth into the cores; these characteristics are consistent with drying shrinkage.

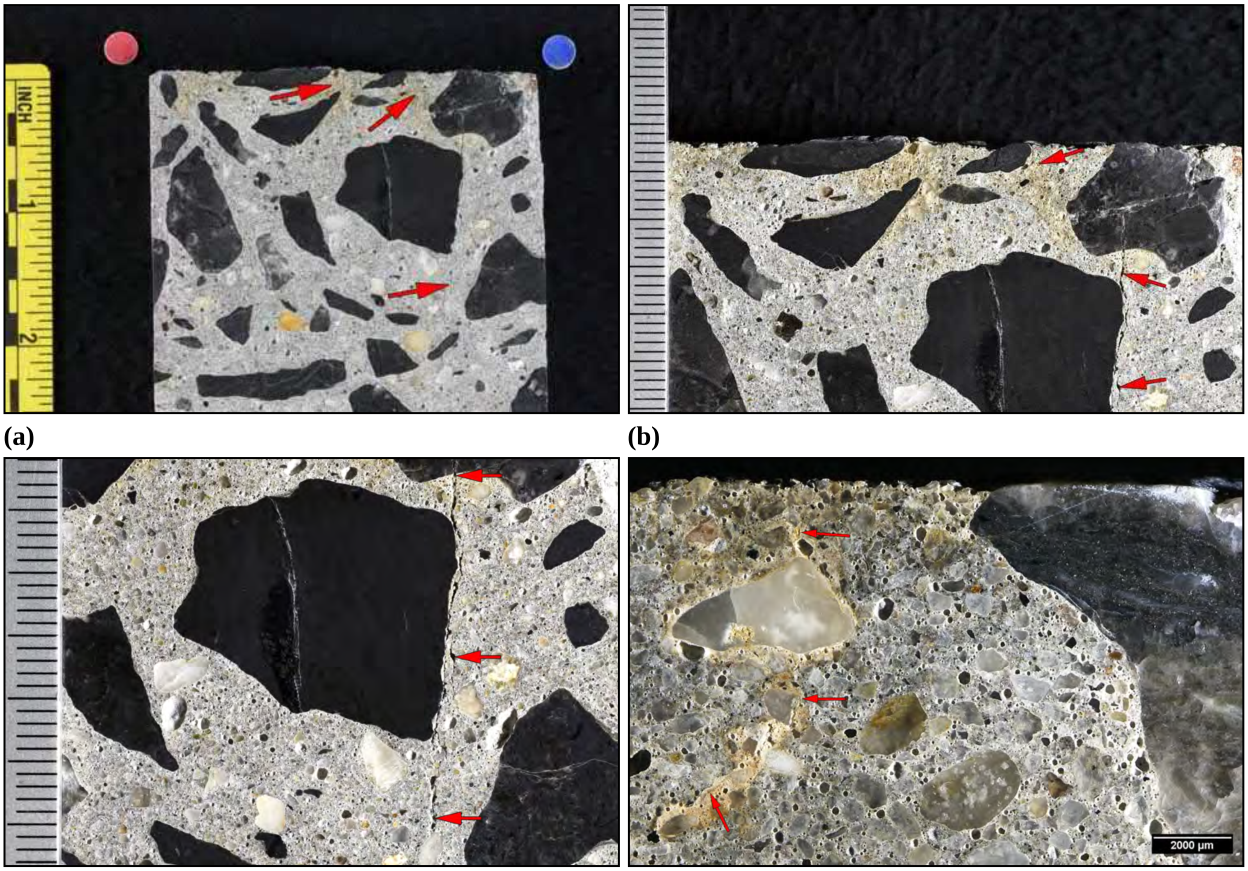
All five cores contain fairly shallow ~25-75 µm (1-3 mil) wide sub-vertical to diagonal microcracks that cut from the top surface into the concrete to depths of 1-5 mm (40-200 mil). These microcracks appear consistent with wear and/or scaling. Salt scaling (due to use of deicer salts) deterioration typically manifests as these types of microcracks in the near-surface region of the concrete.

No original surface is present on any of the cores to evaluate microcracks associated with improper finishing or with inadequate curing. No plastic shrinkage cracks or microcracks were observed in the cores.

Table 3.2 summarizes sub-vertical cracks and sub-vertical to diagonal microcracks in each core.
Figure 4 shows examples of sub-vertical cracks in Core #14 and sub-vertical microcracks in Core #21.
Figure 5 shows examples of sub-vertical to diagonal microcracks in the near surface of the cores.

Table 3.2 Summary of Cracks and/or Microcracks in Each Core

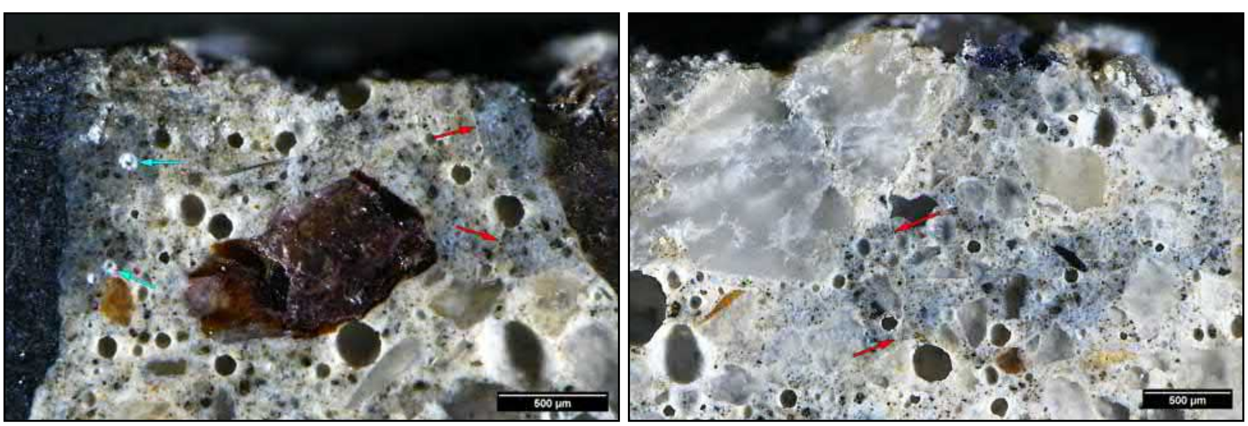
Core ID	Cracks	Microcracks
Core #5	None present	Few microcracks in top 1 mm (40 mil)
Core #9	None present	Few microcracks in top 3 mm (120 mil)
Core #14	Two cracks to 12 mm (½ in.) and 50 mm (2 in.) depth	Few microcracks in top 2 mm (80 mil)
Core #19	None present	Few microcracks in top 5 mm (200 mil)
Core #21	None present	Few microcracks to 9 mm (⅜ in.) depth Few microcracks in top 2 mm (80 mil)



(a) (b)

(c) (d)

Figure 4. Images showing examples of sub-vertical cracks or microcracks in Core #14 and Core #21. (a) Photograph showing sub-vertical cracks (red arrows) on the polished surface of Core #14. Scale shows increments in inches. (b) Photograph showing detail of sub-vertical crack (red arrows) on the polished surface of Core #14. (b) Photograph showing sub-vertical crack (red arrows) detail below area shown in (b). Scale in (b) and (c) shows millimeter increments. (c) Reflected light photomicrograph showing sub-vertical microcrack (red arrows) on the polished surface of Core #21.



(a) (b)

Figure 5. Reflected light photomicrographs showing examples of sub-vertical to diagonal microcracks (red arrows) on the polished surface and in the near-surface region of Core #5. Blue arrows in (a) indicate ettringite in voids.

3.3 *Alkali-Silica Reaction (ASR) and Related Cracks and Microcracks*

Core #14 and Core #21 exhibit evidence of ASR. In both cores, the severity of ASR is rated *minor* following a rating scheme developed by DRP (**Table 3.3a**) and assessed to show *Stage IV* ASR using a rating scheme developed by Katayama (2020) (**Table 3.3b**). No evidence of ASR is observed in Core #5, Core #9 or Core #19.

Table 3.3a DRP Criteria for Severity of ASR Damage

Severity	Criteria
Absent	No reaction rims, microcracks or cracks associated with ASR
Negligible	Only reaction rims observed
Trace	ASR gel rarely observed lining voids near aggregate particles
Minor	ASR gel occasionally around aggregate rims, in voids and in rare microcracks
Moderate	Microcracks with ASR gel commonly observed
Severe	Cracks with ASR gel observed cutting through paste

Table 3.3b Petrographic Stages of ASR (after Katayama, 2020)

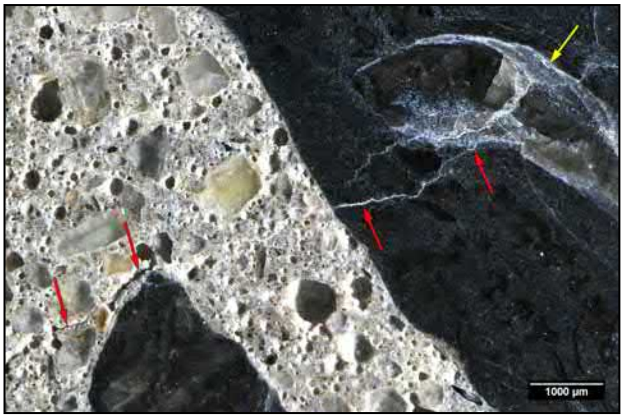
Stage	Criteria
I	Formation of reaction rims within aggregate particles
II	Halo of ASR sol/gel and/or darkening of paste around aggregate particles
III	Cracking of aggregate
IV	Gel-filled cracks cut from aggregate into paste
V	Gel fills voids, cracks distal to aggregate particles
VI	Development of gel-filled cracks between aggregate particles

ASR in both cores is associated with siliceous limestone particles in the crushed limestone coarse aggregate. The siliceous material in the reactive limestone particles is strained quartz and chert.

In Core #14 and Core #21, evidence of ASR is present in the form of ASR gel in rare microcracks extending outwardly from reactive coarse aggregate particles and ASR gel lining to filling rare voids adjacent to reactive coarse aggregate particles. Gel-filled microcracks extend through reactive aggregate particles and cut through the paste beyond particles for distances of 2-5 mm (80-200 mil).

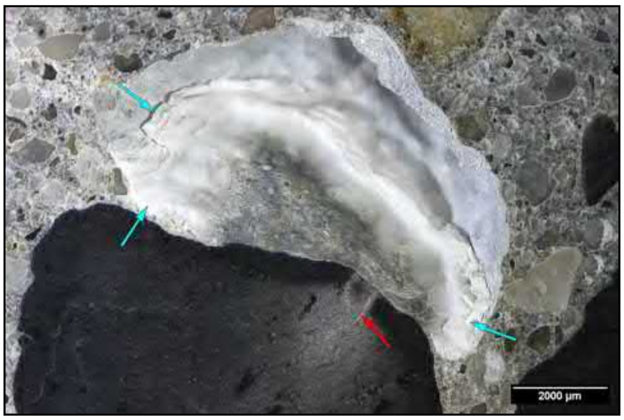
The extent of ASR is limited and, based on the age of the concrete (~40 years), the reaction does not appear to play a significant role in the durability or performance of the concrete pavement.

Figure 5 shows examples of ASR features in Core #14 and Core #21.

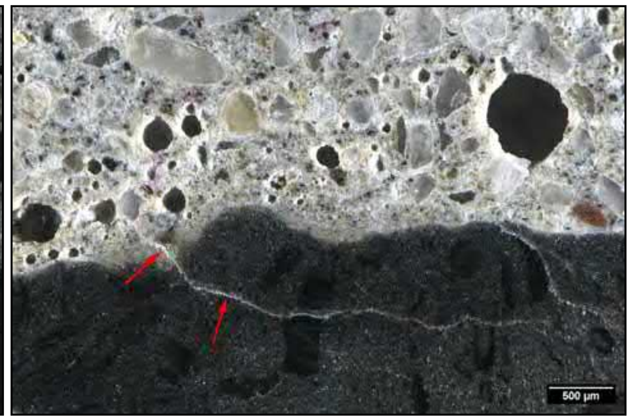


(a)

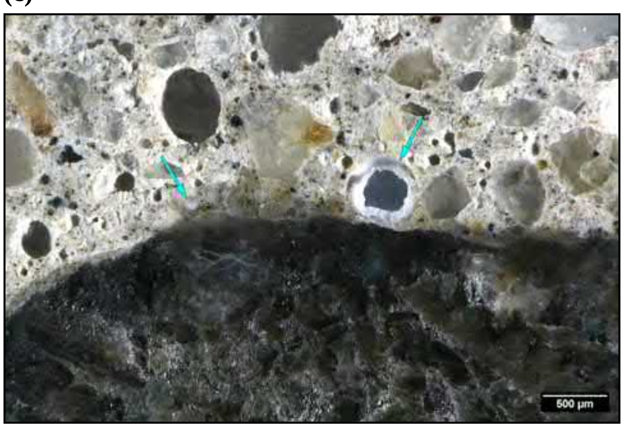
(b)



(c)



(d)



(e)

Figure 5. Images showing ASR features in Core #14 and Core #21. (a) Reflected light photomicrograph of Core #14 showing ASR microcrack (red arrows) extending outwardly from reactive coarse aggregate particle. Yellow arrow indicates siliceous material within reactive particle. (b) Reflected light photomicrograph of Core #14 showing ASR gel-filled microcrack (red arrows) extending outwardly from reactive coarse aggregate particle and ASR gel partially filling an adjacent void (blue arrows). (c) Reflected light photomicrograph of Core #21 showing ASR gel (blue arrows) lining a void adjacent to a reactive coarse aggregate particle. Red arrow indicates ASR gel-filled microcrack extending from reactive particle into void. (d) Reflected light photomicrograph of Core #21 showing ASR gel-filled microcracks (red arrows) extending outwardly from reactive coarse aggregate particle into the paste. (e) Reflected light photomicrograph of Core #21 showing ASR gel lining to filling a couple voids adjacent to a reactive coarse aggregate particle.

3.4 *Components: Paste*

The paste in all five cores consists of hydrated portland cement with no fly ash, slag cement or other supplemental cementitious materials, as confirmed in thin section analysis of Core #14. In all five cores, the paste is locally light beige in the top 4-12 mm (¼ - ½ in.) along microcracks. The remainder of the paste in all fives cores is gray (Munsell Soil Color GLEY 1 6.5/N). Paste throughout all five cores is hard (Mohs 3.5-4). The paste-aggregate bond in all fives cores is moderately weak such that the concrete fractures around ~75% of aggregate particles when struck with a geology hammer.

In Core #14, the amount of residual portland cement is estimated at 10-15% by volume of paste and the amount of calcium hydroxide is estimated at 2-7% by volume of paste. Cement hydration appears normal. Calcium hydroxide is medium to coarse grained. The water-cement ratio (w/c) is estimated at 0.40 ± 0.05 and the paste capillary porosity is moderately low. Limestone fines are common in the paste.

Figure 5 show examples of paste characteristics on polished surfaces of the cores.
Figure 6 show examples of paste characteristics in thin sections prepared from Core #14.

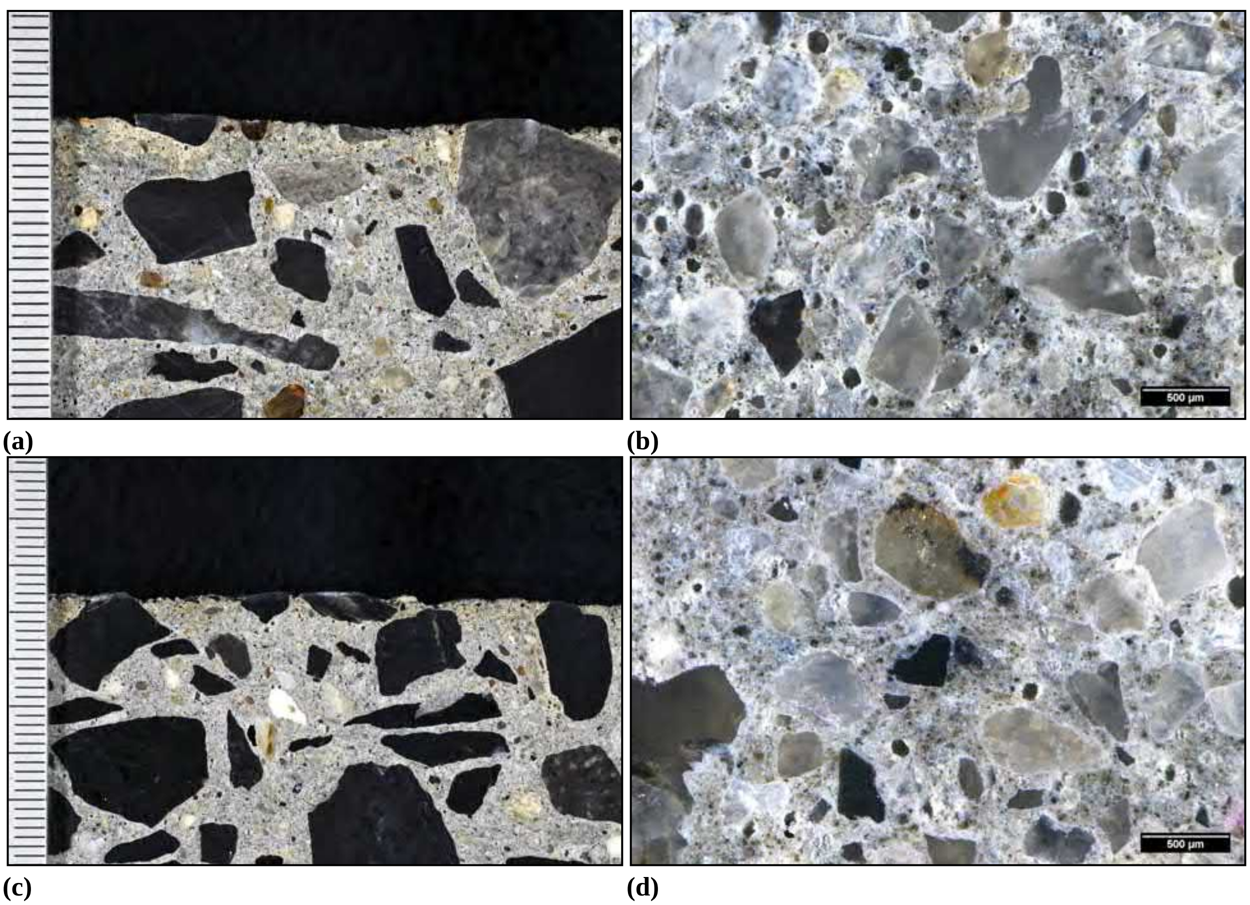
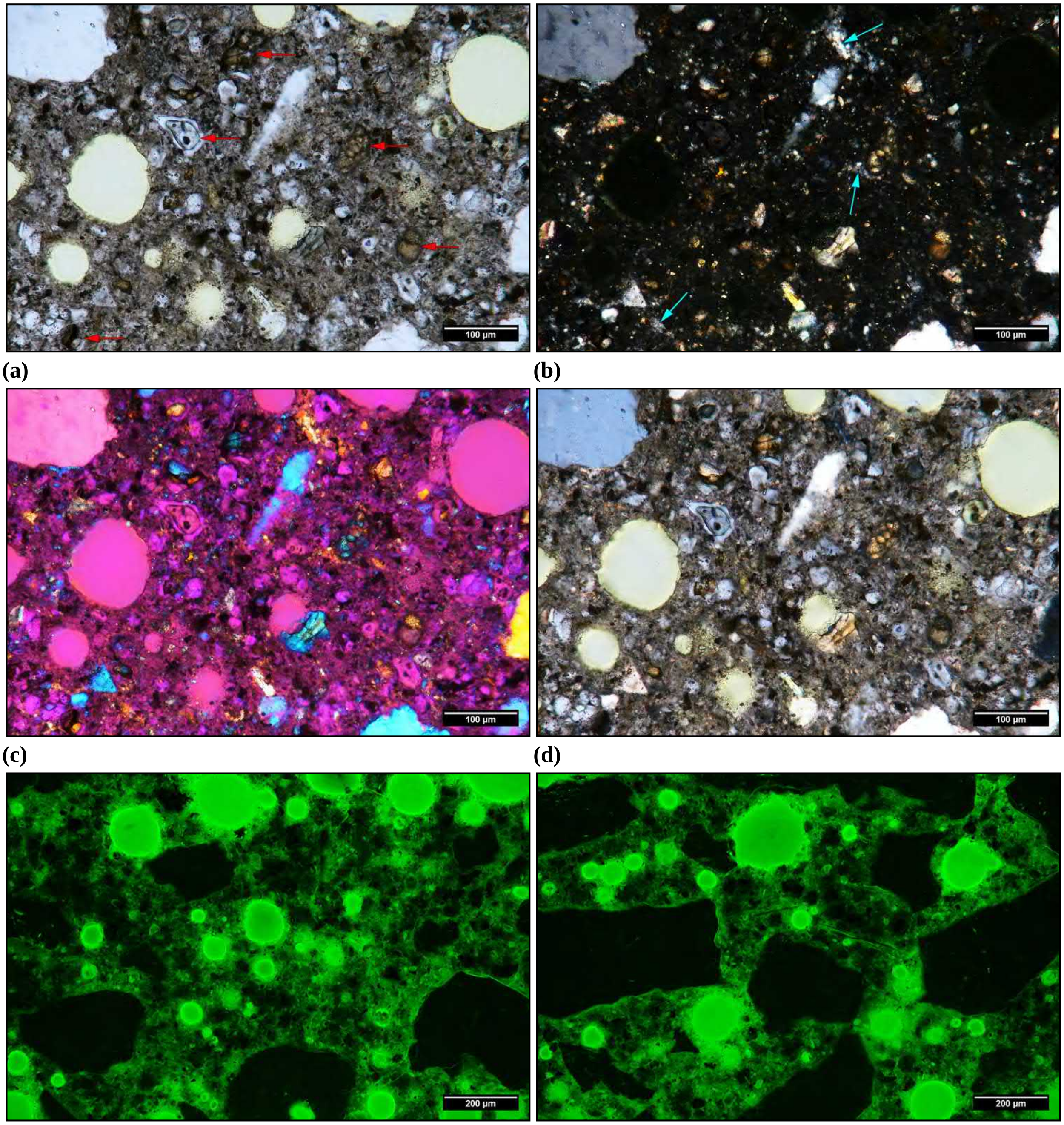


Figure 5. Images showing paste characteristics on polished surfaces. (a) Photograph and (b) reflected light photomicrograph showing paste detail in the top and middle of Core #5 respectively. (c) Photograph and (d) reflected light photomicrograph showing paste detail in the top and middle of Core #19 respectively.



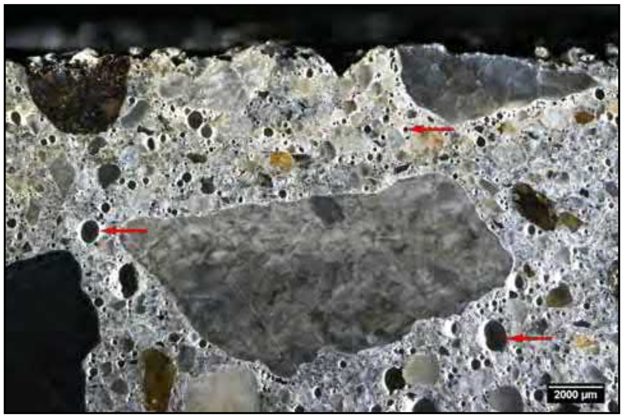
(a) (b) (c) (d) (e) (f)

Figure 6. Images showing paste characteristics in thin section from Core #14. (a) Transmitted light thin section photomicrograph showing paste detail in plane-polarized light. Red arrows indicate residual portland cement particles. (b) Transmitted light thin section photomicrograph showing paste detail from the same area shown in (a) in cross-polarized light. Blue arrows indicate calcium hydroxide. (c) Transmitted light thin section photomicrograph showing paste detail from the same area shown in (a) and (b) in cross-polarized light with the gypsum plate inserted. (d) Transmitted light thin section photomicrograph showing paste detail from the same area shown in (a) (b) and (c) in cross-polarized light with the quarter wave plate inserted. (e) (f) Transmitted fluorescent light photomicrographs of thin sections showing overview of capillary porosity in two different regions in the body of the paste.

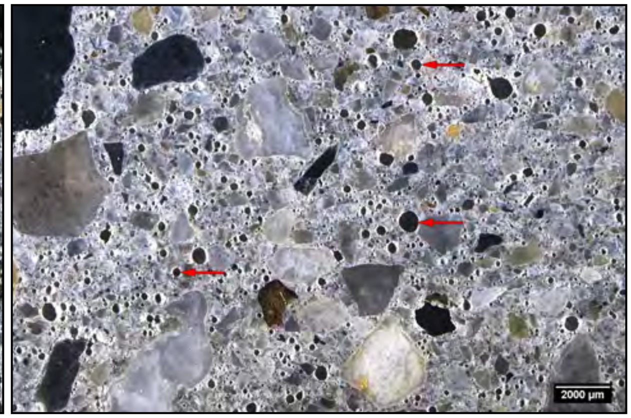
3.5 *Components: Voids*

The concrete in all five cores is air-entrained with the estimated total air content ranging from 5-7% among the cores. The concrete is well consolidated in all five cores. No notably large entrapped voids are present in any of the cores.

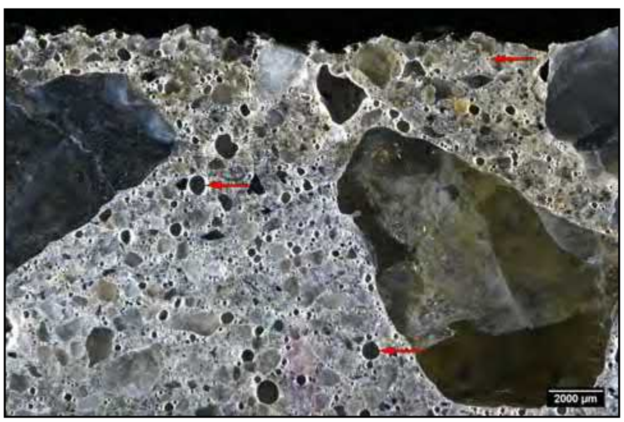
Figure 7 shows examples of voids in the top and body of Core #5 and Core #21.



(a)



(b)



(a)

(b)

Figure 7. Reflected light photomicrographs of polished surfaces of (a) Core #2 and (b) Core #5 showing voids (red arrows) in the body of each core.

3.6 *Components: Aggregates*

The *coarse aggregate* in all five cores is a crushed quarried rock with an observed nominal top size of 19 mm (¾ in.). The coarse aggregate is carbonate in composition and consists of limestone. Some particles exhibit minor to trace amounts of quartz, chert, and/or pyrite. Particles containing siliceous material (quartz, chert) are potentially susceptible to ASR; evidence of ASR related to the coarse aggregate is documented in *Section 3.3*. No particles are potentially susceptible to alkali-carbonate reaction (ACR). Coarse aggregate distribution is generally uniform and aggregate gradation is somewhat uneven with a low volume of intermediate sized particles. Core #19 exhibits darker, more angular particles though the rock type remains the same. The *fine aggregate* is a siliceous natural sand that consists predominately of quartz with minor amounts of quartzite, feldspar, granitic rocks, mica and chert. Quartz, quartzite, granitic rocks and chert are potentially susceptible to ASR though no ASR is observed associated with the fine aggregate.

Figure 8 shows examples of coarse and fine aggregate in Core #5.

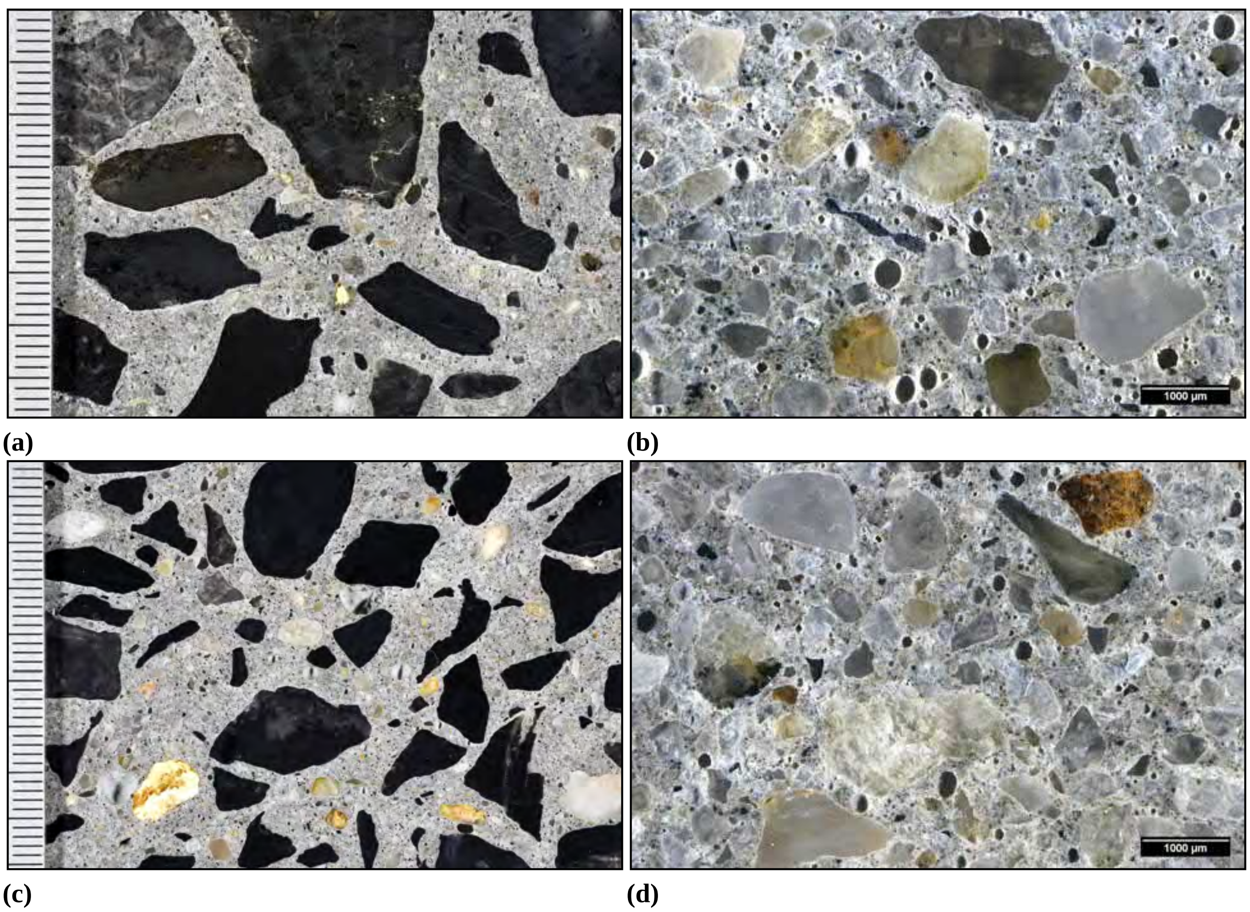


Figure 8. Images showing examples of coarse and fine aggregate. (a) Photograph and (b) reflected light photomicrograph of the polish surface of Core #21 showing detail of the coarse and fine aggregate, respectively. (c) Photograph and (d) reflected light photomicrograph of the polish surface of Core #19 showing detail of the coarse and fine aggregate, respectively. Scale in (a) and (b) shows millimeter increments.

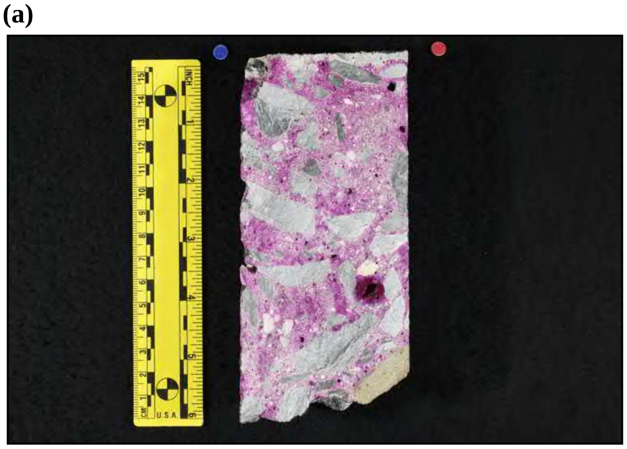
3.7 *Secondary Deposits*

The paste is carbonated in the top 1 mm (40 mil) of each of the cores. Deeper paste carbonation is observed along sub-vertical microcracks to depths of 4-6 mm (160-240 mil) from the top surfaces. Ettringite is occasionally observed lining voids in the near-surface region and in the body of the cores, indicating the concrete has experienced prolonged periods of moisture. ASR gel deposits are observed in Core #14 and Core #21; ASR features are detailed in Section 3.3. No additional secondary deposits are observed within the cores.

Figure 9 shows photographs of the phenolphthalein stained surfaces of the cores.
Figure 10 shows examples of ettringite in voids within the cores.

(a)

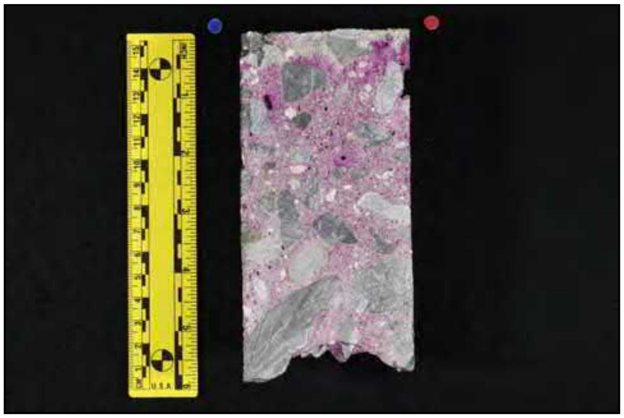
(b)



(c)

(d)

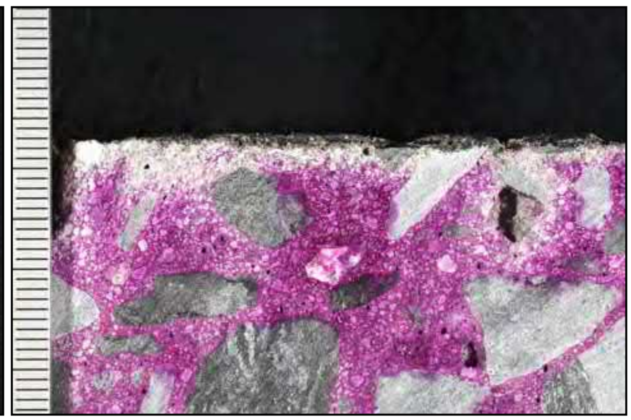
Figure 9. Images showing phenolphthalein-stained surfaces of each core. Photographs showing (a) overview and (b) detail of phenolphthalein-stained surfaces of Core #5. Photographs showing (c) overview and (d) detail of phenolphthalein-stained surfaces of Core #9. The small and large divisions on the yellow scale in (a) and (c) are in centimeters and inches, respectively. The scale in (b) and (d) shows millimeter increments.



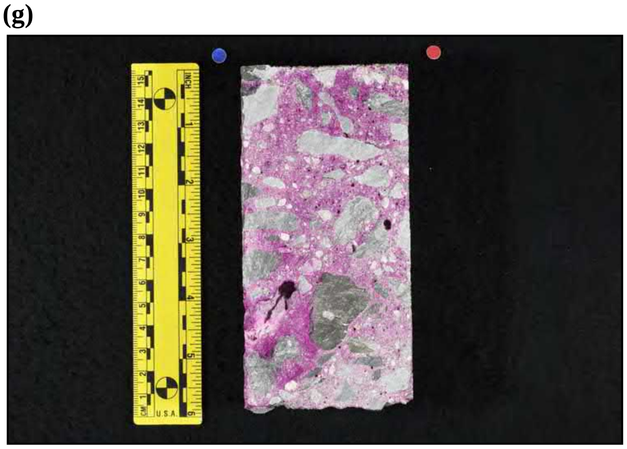
(e)

(f)

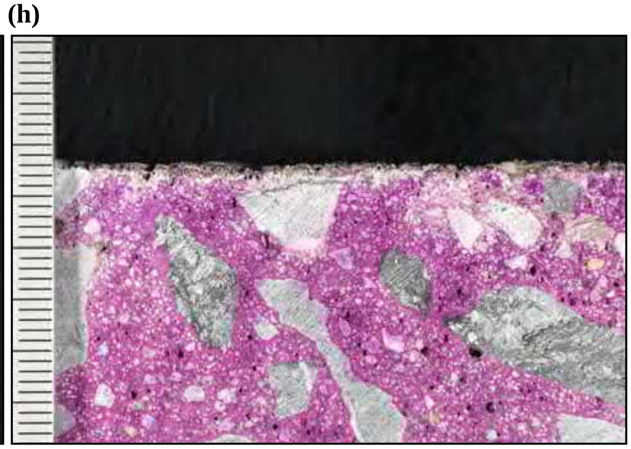
(g)



(h)

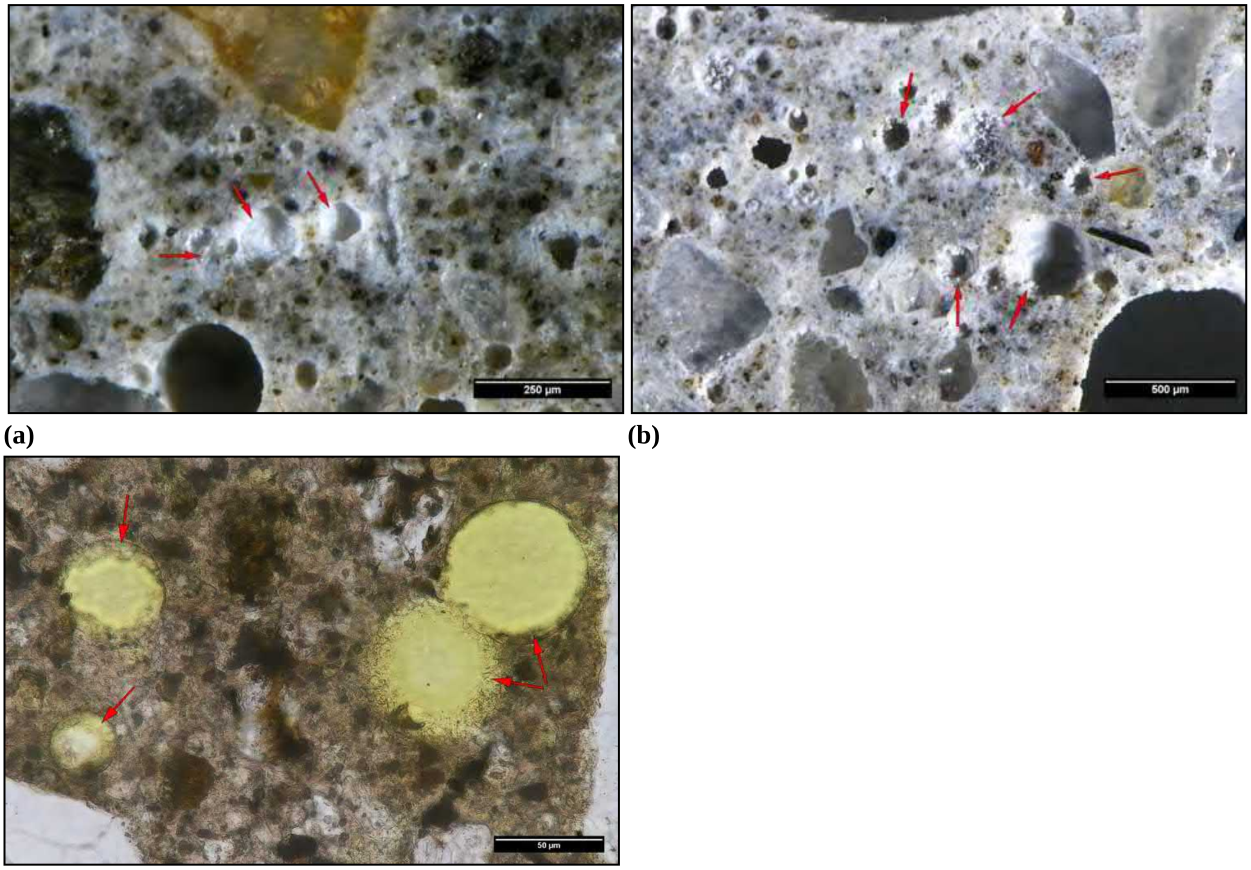


(i)



(j)

Figure 9 (cont'd). Images showing phenolphthalein-stained surfaces of each core. Photographs showing (e) overview and (f) detail of phenolphthalein-stained surfaces of Core #14. Photographs showing (g) overview and (h) detail of phenolphthalein-stained surfaces of Core #19. Photographs showing (i) overview and (j) detail of phenolphthalein-stained surfaces of Core #21. The small and large divisions on the yellow scale in (e) (g) and (i) are in centimeters and inches, respectively. The scale in (f) (h) and (j) shows millimeter increments.



(a) (b)

(c)

Figure 10. Images showing examples of ettringite in voids. Reflected light photomicrographs of the polished surface of (a) Core #5 and (b) Core #19 showing white ettringite deposits (red arrows) in voids. (c) Plane-polarized transmitted light thin section photomicrograph showing ettringite (red arrows) in voids in Core #14.

4.0 Conclusions

The findings above indicate that the concrete appears to be of good quality and is in good condition excluding significantly deteriorated concrete top surfaces. All fives cores exhibit a deteriorated top surface that exhibits no original surface and shows coarse aggregate particles exposed in high relief; these surfaces may be of concern for aesthetic or ride-ability issues.

Core #14 and Core #21 exhibit minor cracks and microcracks in the top portion of the concrete that are attributed to drying shrinkage. All five cores contain fairly shallow sub-vertical to diagonal microcracks that cut from the top surface to depths of 1-5 mm (40-200 mil) into the concrete. These microcracks are consistent with wear and/or scaling. Salt scaling deterioration typically manifests as these types of microcracks in concrete exposed to deicer salts.

Acid-soluble chloride analysis results provided by **NDT** show elevated chloride content at the surface of companion cores (**Table 1.2**). Chloride content significantly decreases with depth in the concrete suggesting the chloride is external to the concrete such as by deicer salts. Sub-vertical to diagonal microcracks in the top 1-5 mm of the submitted cores is consistent with salt scaling due to exposure to deicer salts.

Core #14 and Core #21 exhibit ASR with no significant damage. ASR gel is present in rare microcracks extending outwardly from reactive coarse aggregate particles and ASR gel lines to fills rare voids adjacent to reactive coarse aggregate particles. In both cores, the severity of ASR is rated *minor* following a rating scheme developed by DRP and assessed to show *Stage IV* ASR using a rating scheme developed by Katayama (2020). No evidence of ASR is observed in Core #5, Core #9 or Core #19.

Other than minor ASR and salt scaling, no evidence of other deterioration mechanisms (such as freeze-thaw damager, chemical attack, etc.) is observed.

This concludes work performed on this project to date.

Meredith Strow

Meredith Strow
Senior Petrographer

Grand Central Parkway Deck Rehabilitation Petrography

Appendices

1. RECEIVED CONDITION	
ORIENTATION & DIMENSIONS	Sample is a vertical core measuring ~70 mm (2 ¾ in.) in diameter and ~150 mm (5 ⅞ in.) in length (**Figure A1**).
SURFACES	The top surface is a worn concrete surface that exhibits exposed coarse aggregate particles in high relief, and the bottom surface is a rough, uneven, fractured surface (**Figure A1**, **Figure A2**).
GENERAL CONDITION	The core was received intact in one piece (**Figure A1, Figure A3**).

2. EMBEDDED OBJECTS	
GENERAL	None present.

3. CRACKING	
MACROSCOPIC	None present.
MICROSCOPIC	Few sub-vertical to diagonal ~25-75 µm (1-3 mil) wide microcracks are present in the top 1 mm (40 mil) of the core and pass around aggregate particles (**Figure A4**).

4. PASTE OBSERVATIONS	
POLISHED SURFACE	Paste in the top 6 mm (¼ in.) is locally light beige; remainder of paste is light gray (Munsell Soil Color GLEY 1 7/N) (**Figure A5**). Paste throughout the core is hard (Mohs 3.5-4). The paste has a smooth texture and sub-vitreous luster.
FRESH FRACTURE	Freshly fractured surfaces show same coloration and luster, and exhibit a moderately weak paste-aggregate bond such that the concrete fractures around ~75% of coarse aggregate particles when struck with a geology hammer in the petrographic laboratory (**Figure A6**).
THIN SECTION	Thin section evaluation was not performed.
ESTIMATED W/C	Thin section evaluation was not performed; w/c was not estimated.

5. COARSE AGGREGATE	
PHYSICAL PROPERTIES	The coarse aggregate is a crushed carbonate rock with a 19 mm (¾ in.) nominal top size (**Figure A7**). The rocks are hard and competent. The particles are equant to elongated in shape with angular to sub-angular edges and rough surfaces. Aggregate distribution is somewhat non-uniform and gradation is fairly uneven with a low volume of intermediate sized particles. No aggregate segregation is observed.
ROCK TYPES	The coarse aggregate is carbonate in composition and consists of limestone. Some particles exhibit minor to trace amounts of quartz, chert, and/or pyrite. Particles containing siliceous material (quartz, chert) are potentially susceptible to alkali-silica reaction (ASR). No particles are potentially susceptible to alkali-carbonate reaction (ACR); carbonate particles do not contain dolomite or textural characteristics typical of potentially reactive aggregate.
OTHER FEATURES	No evidence of ASR or ACR is observed. No deleterious coatings or encrustation are observed. Rare low w/c mortar coatings are observed (**Figure A8**).

6. FINE AGGREGATE	
PHYSICAL PROPERTIES	The fine aggregate is a natural siliceous sand (**Figure A9**). Particles are hard and competent. The particles are equant in shape with sub-rounded to sub-angular edges. Aggregate gradation is fairly uniform and gradation is fairly even.
ROCK TYPES	The natural sand is siliceous in composition and consists predominately of quartz with minor amounts of quartzite, feldspar, granitic rocks, mica (muscovite and biotite), and chert with trace amounts of other rock and mineral particles. Quartz, quartzite, granitic rocks and chert are potentially susceptible to ASR. No particles are potentially susceptible to ACR.
OTHER FEATURES	No evidence of ASR or ACR is observed. No deleterious coatings or encrustation are observed. No low w/c mortar coatings are observed.

7. VOIDS	
VOID SYSTEM	The concrete is air-entrained and has an estimated 6-7% total air content. Several spherical voids are observed throughout the depth of the core (**Figure A10**). Few entrapped voids are occasionally present throughout the core. The concrete is well consolidated with no notably large entrapped voids. Air void clustering is observed along the boundaries of coarse aggregate particles. Gaps between coarse aggregate and paste is observed in regions of air void clustering.
VOID FILLINGS	Ettringite occasionally lines voids throughout the core (**Figure A11**).

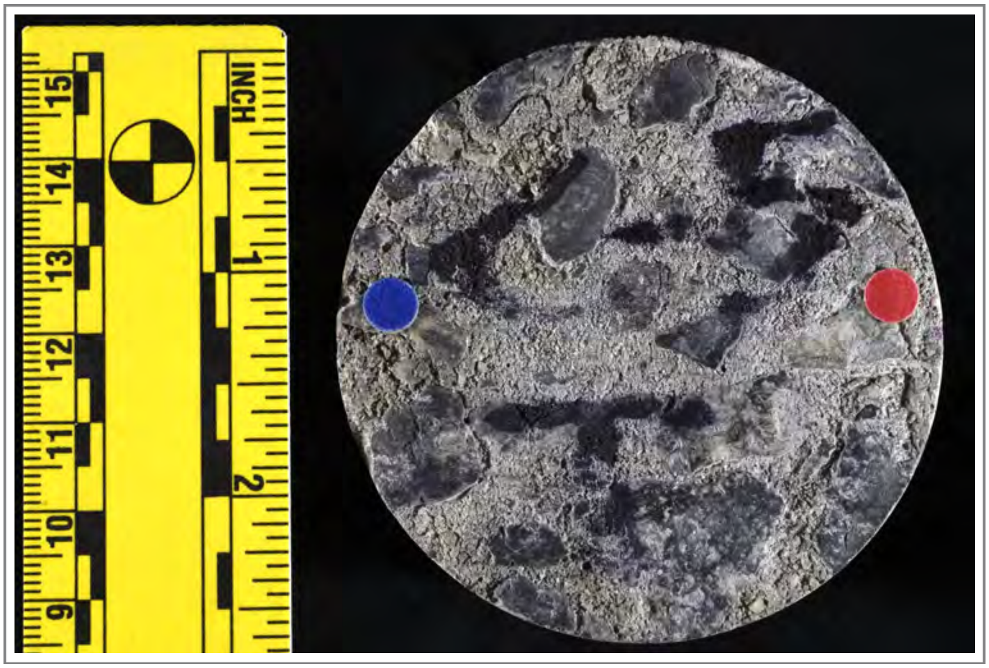
8. SECONDARY DEPOSITS	
PHENOLPHTHALEIN	The paste is carbonated in the top 1 mm (40 mil) with locally deeper carbonation along sub-vertical microcracks (**Figure A12**). Phenolphthalein staining was applied to a freshly saw-cut cross-sectional surface of the core to determine general depth of paste carbonation.
SECONDARY DEPOSITS	Other than ettringite in voids, no additional secondary deposits are observed.

FIGURES

(a)

(b)

Figure A1. Photographs of the core in as-received condition showing (a) an oblique view of the top surface and side of the core with identification labels and (b) the side of the core. The yellow scale is ~150 mm (6 in.) long; the small and large divisions are in centimeters and inches, respectively.


(c)


(d)

Figure A1 (cont'd). Photographs of the core in as-received condition showing (c) top surface of the core and (d) the bottom surface of the core. The red and blue dots in (c) show the orientation of the saw cuts used to prepare the core. The yellow scale is ~150 mm (6 in.) long; the small and large divisions are in centimeters and inches, respectively.

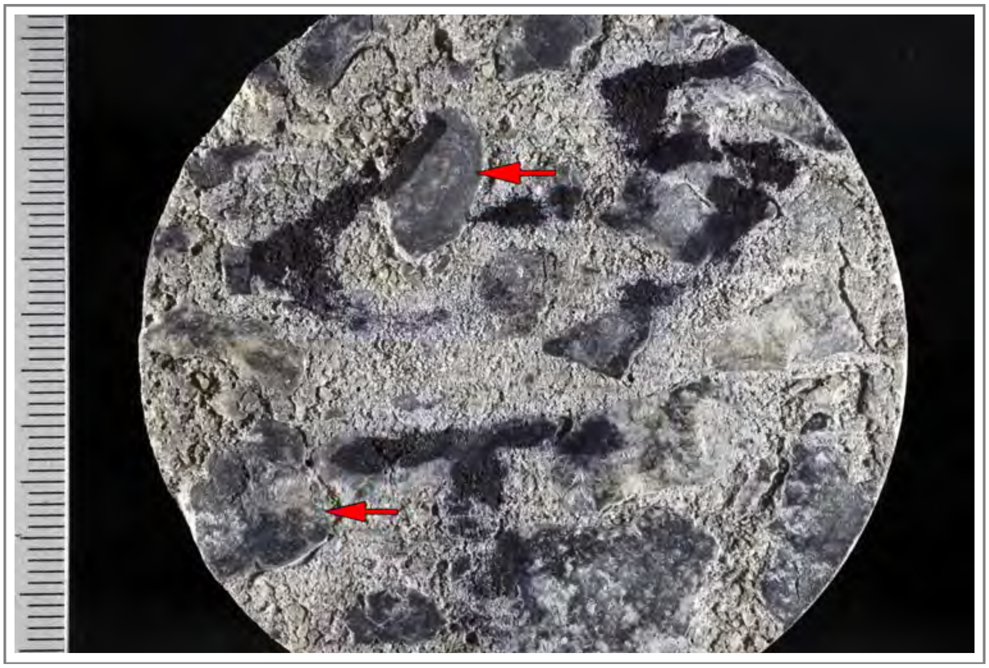


Figure A2. Photograph of the as-received condition of the top surface of the core. Red arrows indicate exposed coarse aggregate particles. Scale shows millimeter increments.

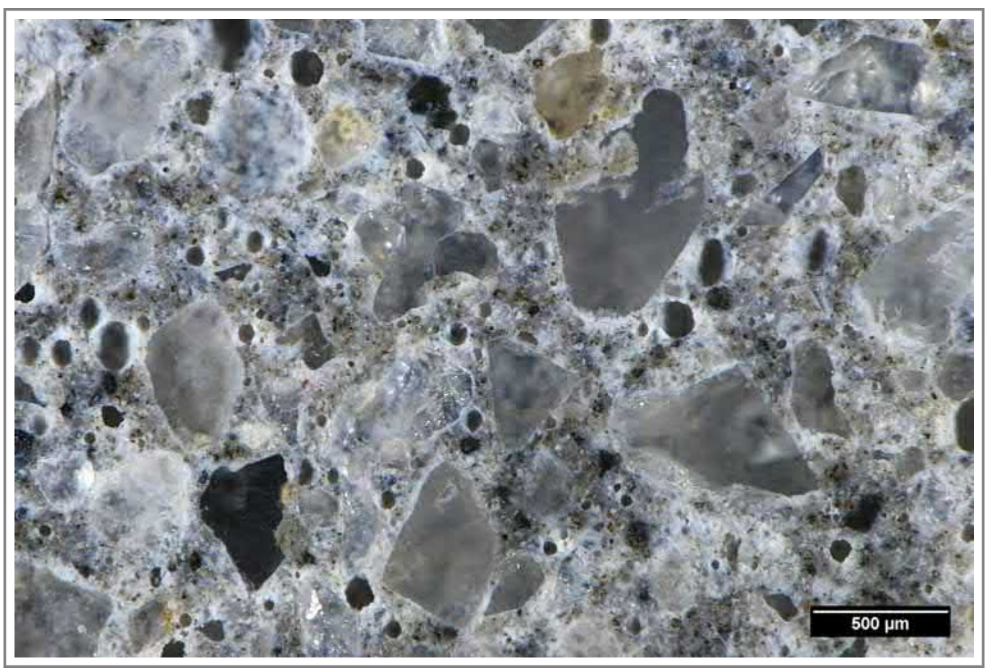
Figure A3. Photograph showing the polished surface of the slab prepared from the core. The red and blue dots show the orientation of the saw cuts used to prepare the core. The yellow scale is ~150 mm (6 in.) long; the small and large divisions are in centimeters and inches, respectively.

(a)

(b)

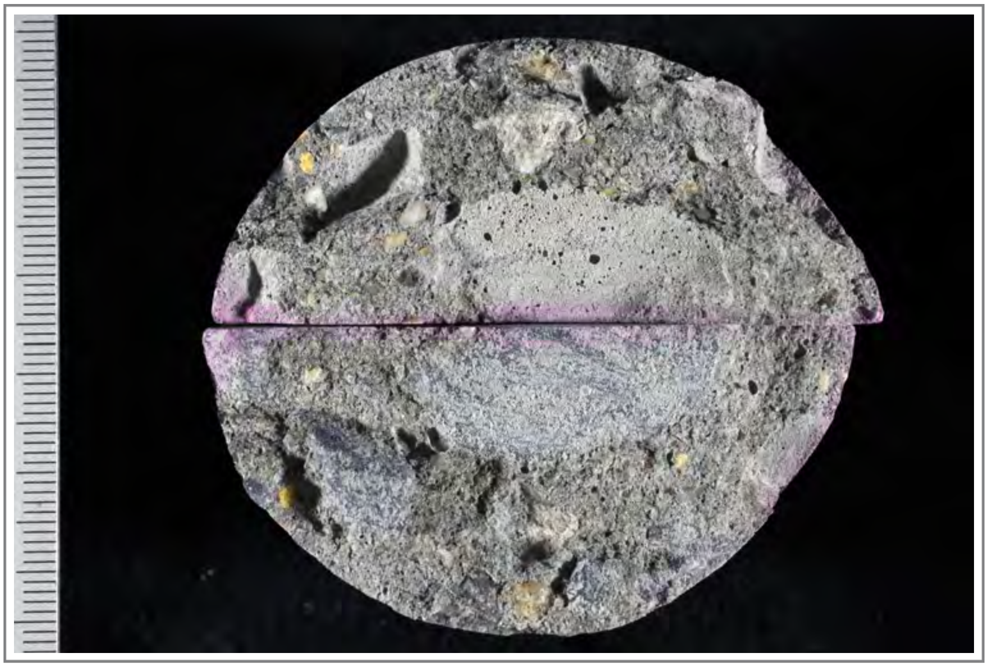
Figure A4. Reflected light photomicrographs showing detail of sub-vertical microcracks (red arrows) in the near-surface region of the paste. Blue arrows in (a) indicate ettringite in voids.

(a)



(b)

Figure A5. Images showing detail of the paste. (a) Photograph showing paste in the near-surface region of the core. Scale shows millimeter increments. (b) Reflected light photomicrograph showing paste detail in the body of the core.



(a)

(b)

Figure A6. Photographs showing (a) overview and (b) detail of freshly fractured concrete surfaces. Scale in both images shows millimeter increments.

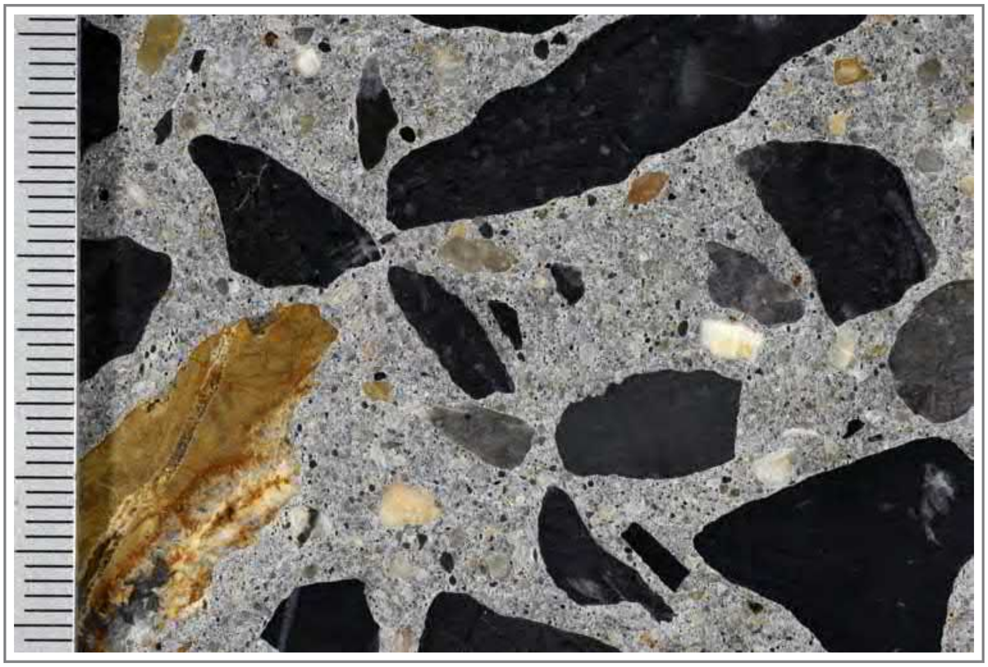


Figure A7. Photograph of the polished surface showing detail of the coarse aggregate. Scale shows millimeter increments.

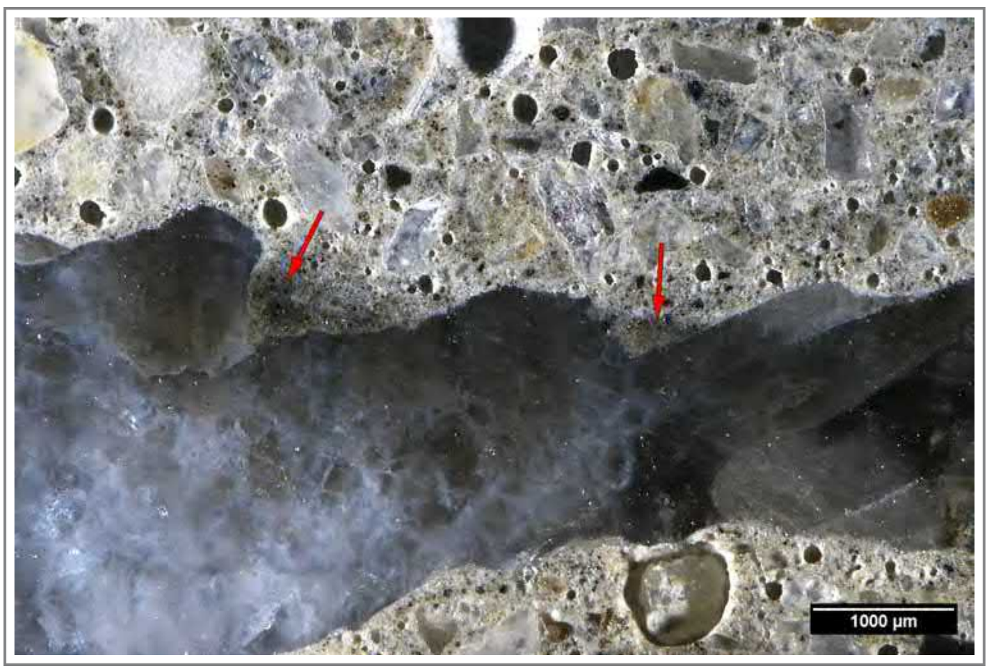


Figure A8. Reflected light photomicrograph of the polished surface showing low w/cm mortar coatings (red arrows) along a coarse aggregate particle.

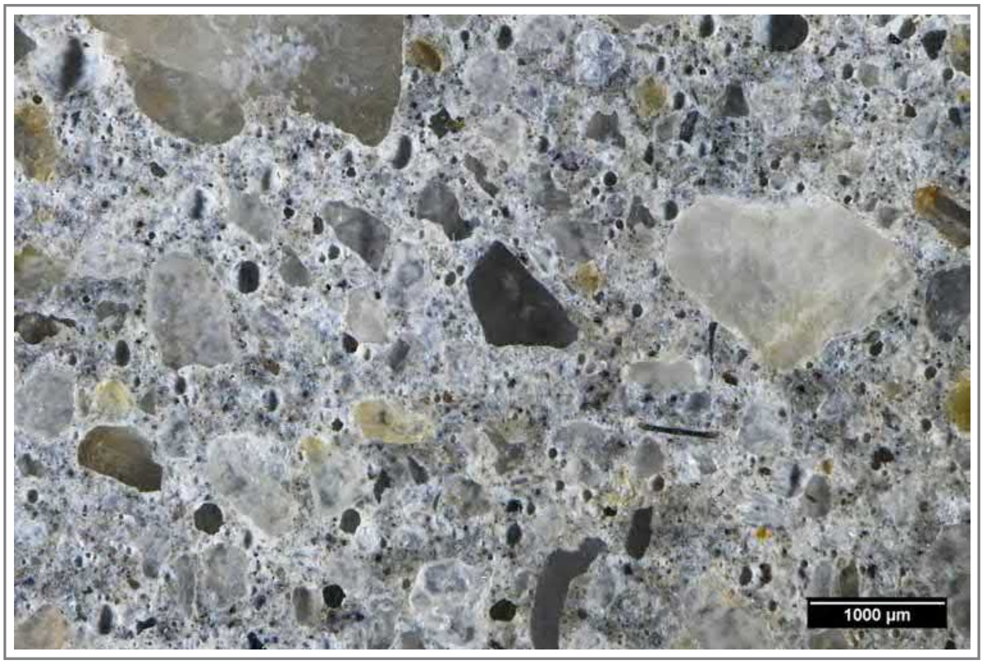


Figure A9. Reflected light photomicrograph of the polished surface showing detail of the fine aggregate.

(a)

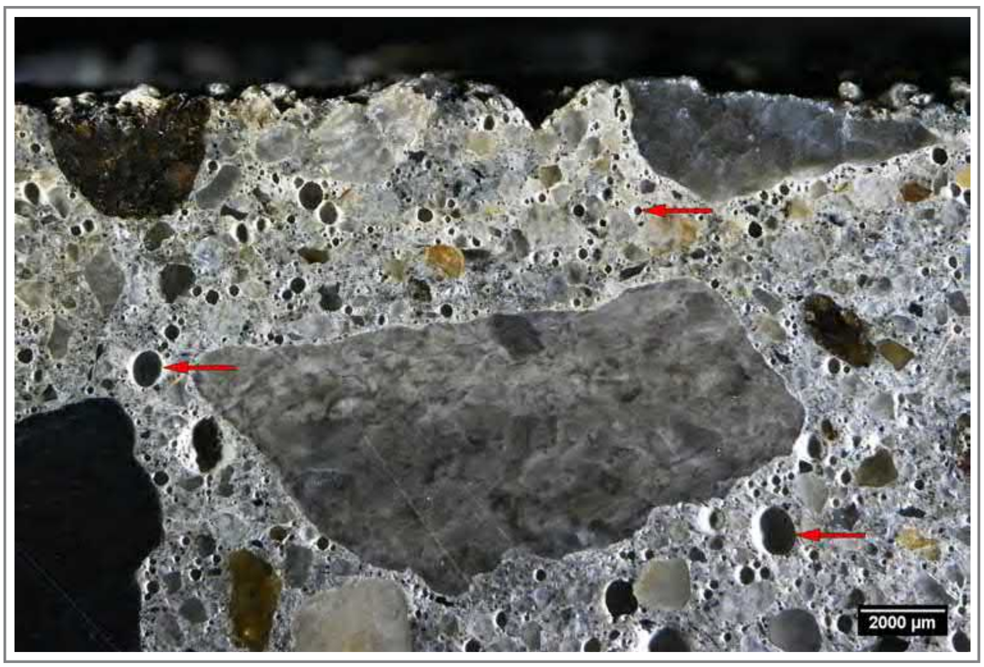
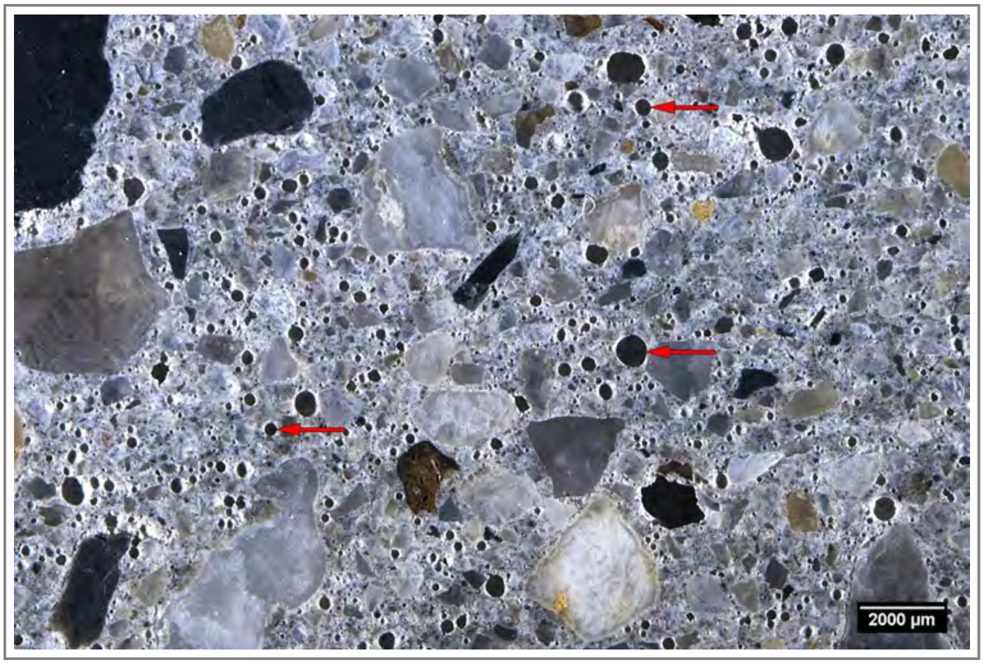
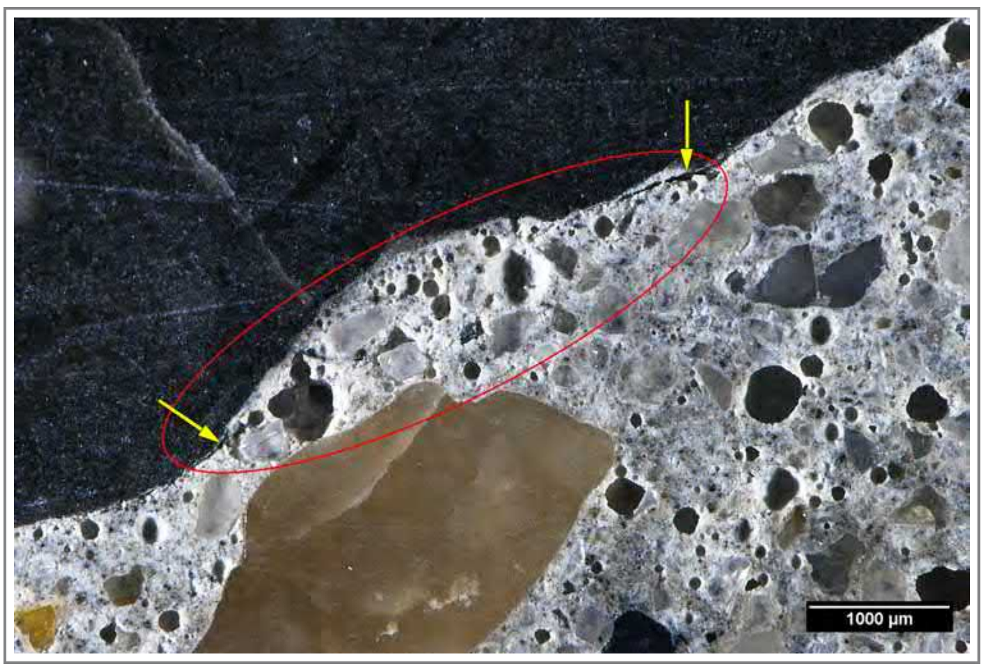


Figure A10. Images showing detail of voids within the core. (a) Reflected light photomicrograph showing detail of voids (red arrows) in the top portion of the core.



(b)



(c)

Figure A10 (cont'd). Images showing detail of voids within the core. (b) Reflected light photomicrograph showing detail of voids (red arrows) in the middle of the core. (c) Reflected light photomicrograph showing detail of air void clustering (encircled red) along coarse aggregate particle and gaps between aggregate and paste (yellow arrows).

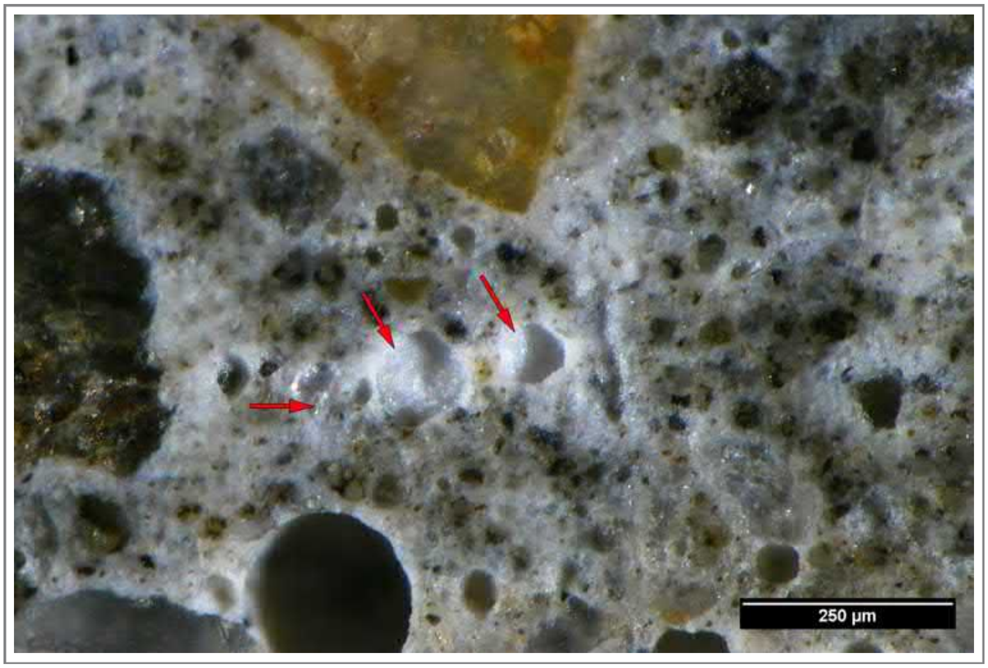


Figure A11. Reflected light photomicrograph of the polished surface showing ettringite (red arrows) in a few voids within the core.

(a)

(b)

Figure A12. Photographs showing (a) overview of phenolphthalein-stained cross-sectional surface of the core, and (b) detail of stained surface at the top of the core. The yellow scale in (a) is ~150 mm (6 in.) long; the small and large divisions are in centimeters and inches, respectively. The scale in (b) shows millimeter increments.

1. RECEIVED CONDITION	
ORIENTATION & DIMENSIONS	Sample is a vertical core measuring ~70 mm (2 ¾ in.) in diameter and ~150 mm (5 ⅞ in.) in length (**Figure B1**).
SURFACES	The top surface is a worn concrete surface that exhibits exposed coarse aggregate and fine aggregate particles in high relief, and the bottom surface is a rough, uneven, fractured surface (**Figure B1**, **Figure B2**).
GENERAL CONDITION	The core was received intact in one piece (**Figure B1, Figure B3**).

2. EMBEDDED OBJECTS	
GENERAL	None present.

3. CRACKING	
MACROSCOPIC	None present.
MICROSCOPIC	Few sub-vertical to diagonal ~25-75 µm (1-3 mil) wide microcracks are present in the top 3 mm (120 mil or ⅛ in.) of the core and pass around aggregate particles (**Figure B4**). One sub-vertical ~25-125 µm (1-5 mil) wide microcrack is present in the top 50 mm (2 in.) of the core and passes mostly around aggregate particles (**Figure B4**).

4. PASTE OBSERVATIONS	
POLISHED SURFACE	Paste in the top 4 mm (¼ in.) is locally light beige; remainder of paste is light gray (Munsell Soil Color GLEY 1 7/N) (**Figure B5**). Paste throughout the core is hard (Mohs 3.5-4). The paste has a smooth texture and sub-vitreous luster.
FRESH FRACTURE	Freshly fractured surfaces show same coloration and luster, and exhibit a moderately weak paste-aggregate bond such that the concrete fractures around ~75% of coarse aggregate particles when struck with a geology hammer in the petrographic laboratory (**Figure B6**).
THIN SECTION	Thin section evaluation was not performed.
ESTIMATED W/C	Thin section evaluation was not performed; w/c was not estimated.

5. COARSE AGGREGATE	
PHYSICAL PROPERTIES	The coarse aggregate is a crushed carbonate rock with a 19 mm (¾ in.) nominal top size (**Figure B7**). The rocks are hard and competent. The particles are equant to elongated in shape with angular to sub-angular edges and rough surfaces. Aggregate distribution is somewhat non-uniform and gradation is fairly uneven with a low volume of intermediate sized particles. No aggregate segregation is observed.
ROCK TYPES	The coarse aggregate is carbonate in composition and consists of limestone. Some particles exhibit minor to trace amounts of quartz, chert, and/or pyrite. Particles containing siliceous material (quartz, chert) are potentially susceptible to alkali-silica reaction (ASR). No particles are potentially susceptible to alkali-carbonate reaction (ACR); carbonate particles do not contain dolomite or textural characteristics typical of potentially reactive aggregate.
OTHER FEATURES	No evidence of ASR or ACR is observed. No deleterious coatings or encrustation are observed. Rare low w/c mortar coatings are observed (**Figure B8**).

6. Fine Aggregate

Physical Properties	The fine aggregate is a natural siliceous sand (**Figure B9**). Particles are hard and competent. The particles are equant in shape with sub-rounded to sub-angular edges. Aggregate gradation is fairly uniform and gradation is fairly even.
Rock Types	The natural sand is siliceous in composition and consists predominately of quartz with minor amounts of quartzite, feldspar, granitic rocks, mica (muscovite and biotite), and chert with trace amounts of other rock and mineral particles. Quartz, quartzite, granitic rocks and chert are potentially susceptible to ASR. No particles are potentially susceptible to ACR.
Other Features	No evidence of ASR or ACR is observed. No deleterious coatings or encrustation are observed. No low w/c mortar coatings are observed.

7. Voids

Void System	The concrete is air-entrained and has an estimated 6-7% total air content. Several spherical voids are observed throughout the depth of the core (**Figure B10**). Few entrapped voids are occasionally present throughout the core. The concrete is well consolidated with no notably large entrapped voids.
Void Fillings	Ettringite occasionally lines voids throughout the core (**Figure B11**).

8. Secondary Deposits

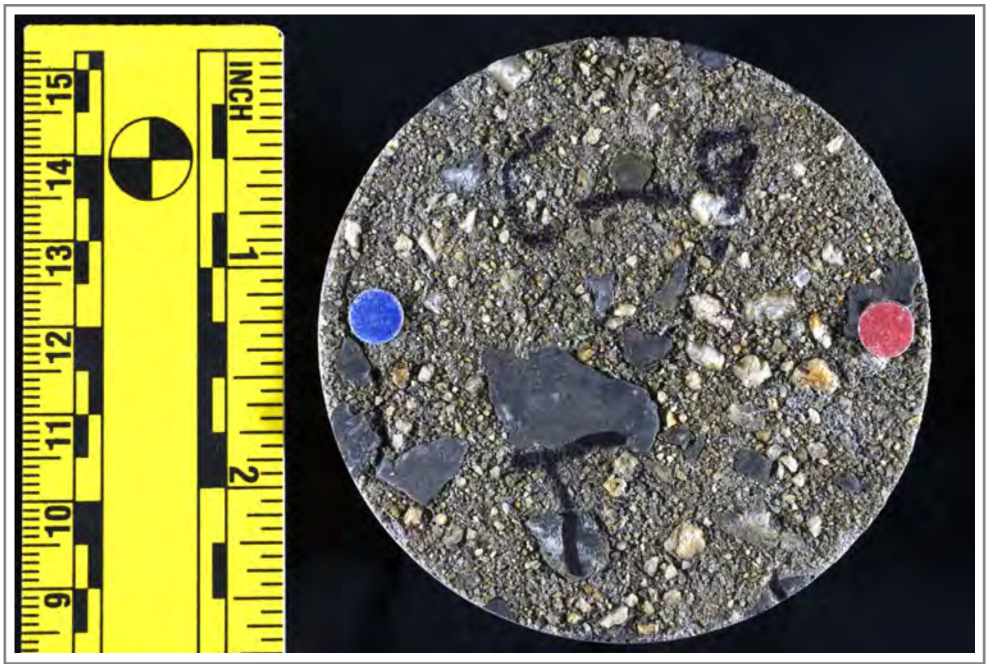
Phenolphthalein	The paste is carbonated in the top 1 mm (40 mil) with locally deeper carbonation along sub-vertical microcracks (**Figure B12**). Phenolphthalein staining was applied to a freshly saw-cut cross-sectional surface of the core to determine general depth of paste carbonation.
Secondary Deposits	Other than ettringite in voids, no additional secondary deposits are observed.

FIGURES

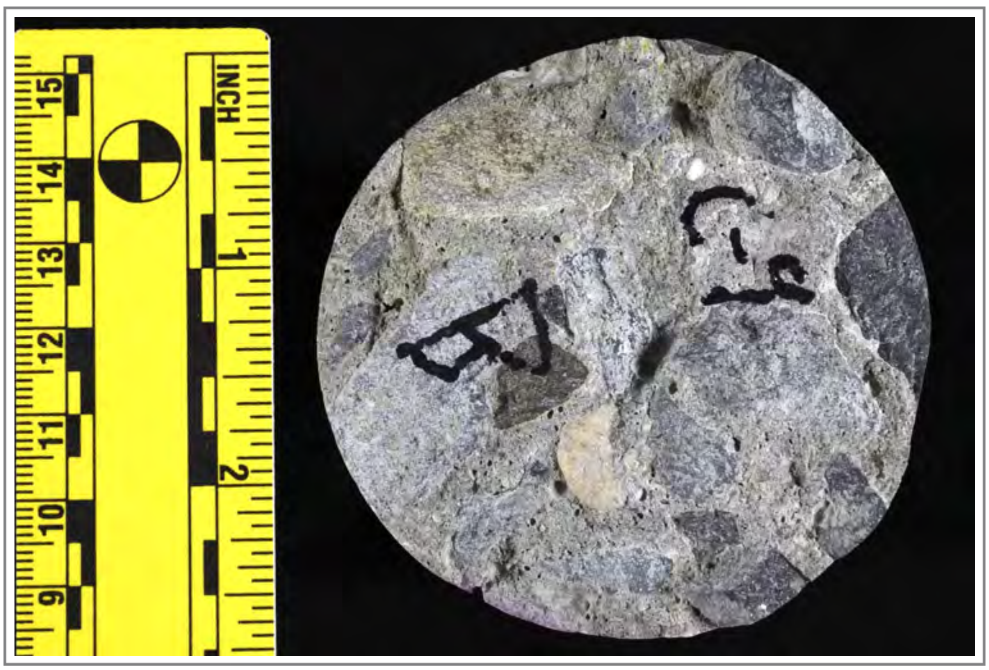
(a)

(b)

Figure B1. Photographs of the core in as-received condition showing (a) an oblique view of the top surface and side of the core with identification labels and (b) the side of the core. The yellow scale is ~150 mm (6 in.) long; the small and large divisions are in centimeters and inches, respectively.



(c)



(d)

Figure B1 (cont'd). Photographs of the core in as-received condition showing (c) top surface of the core and (d) the bottom surface of the core. The red and blue dots in (c) show the orientation of the saw cuts used to prepare the core. The yellow scale is ~150 mm (6 in.) long; the small and large divisions are in centimeters and inches, respectively.

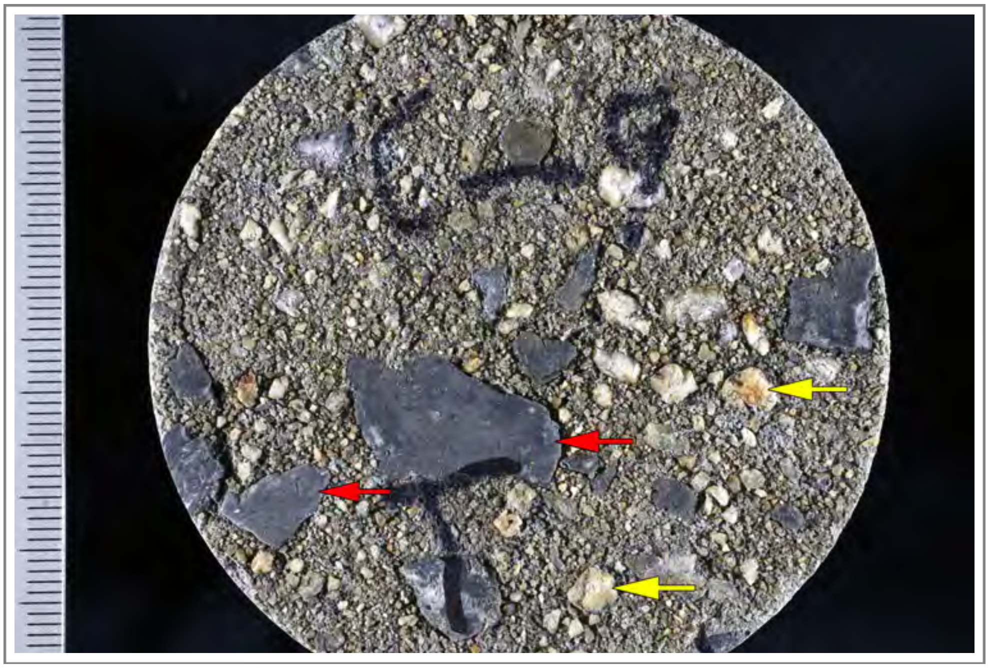


Figure B2. Photograph of the as-received condition of the top surface of the core. Red and yellow arrows indicate exposed coarse and fine aggregate particles, respectively. Scale shows millimeter increments.

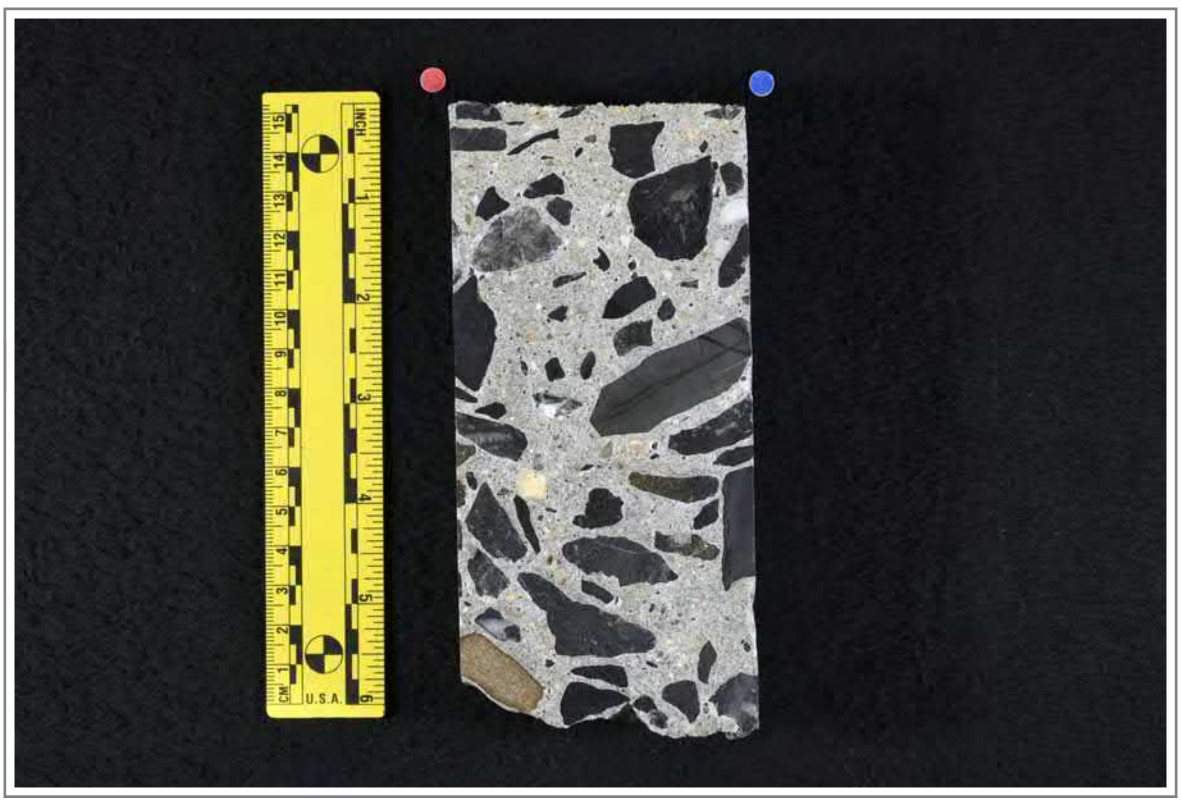
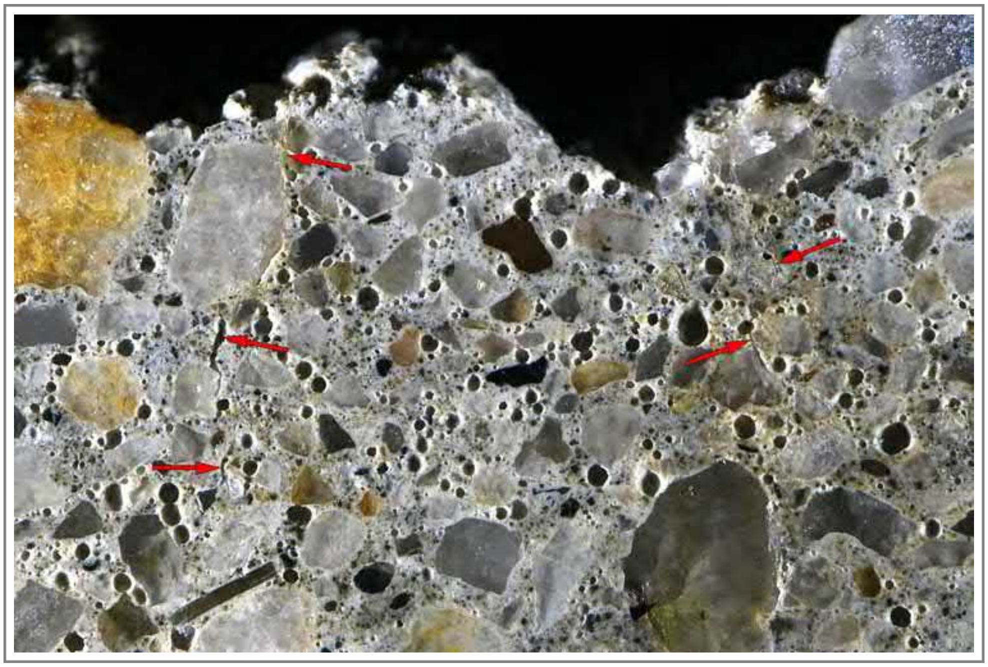


Figure B3. Photograph showing the polished surface of the slab prepared from the core. The red and blue dots show the orientation of the saw cuts used to prepare the core. The yellow scale is ~150 mm (6 in.) long; the small and large divisions are in centimeters and inches, respectively.



(a)

(b)

Figure B4. Reflected light photomicrographs showing detail of sub-vertical microcracks (red arrows) in the near-surface region of the paste. Yellow arrows in (b) indicate microcrack passing through a coarse aggregate particle at the surface.


(a)

(b)

Figure B5. Images showing detail of the paste. (a) Photograph showing paste in the near-surface region of the core. Scale shows millimeter increments. (b) Reflected light photomicrograph showing paste detail in the body of the core.


(a)

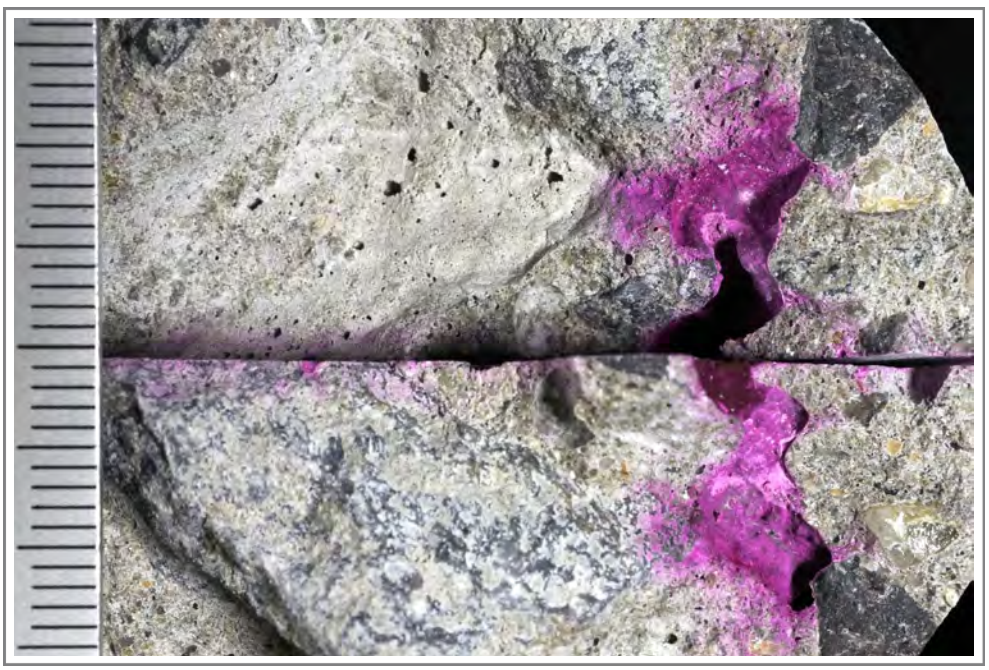

(b)

Figure B6. Photographs showing (a) overview and (b) detail of freshly fractured concrete surfaces. Scale in both images shows millimeter increments.

Figure B7. Photograph of the polished surface showing detail of the coarse aggregate. Scale shows millimeter increments.

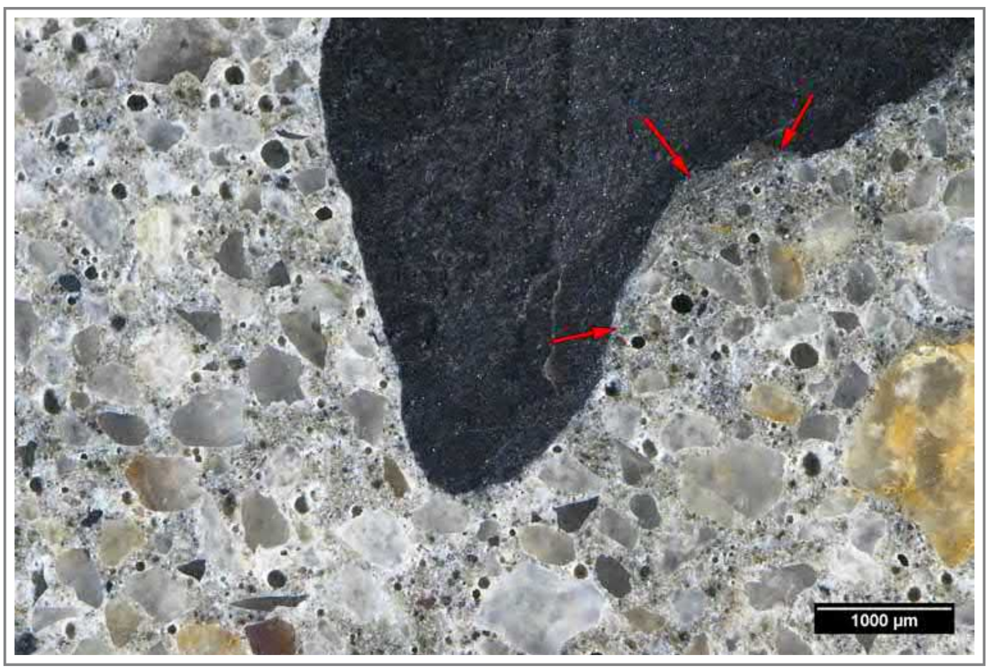


Figure B8. Reflected light photomicrograph of the polished surface showing low w/cm mortar coating (red arrows) along a coarse aggregate particle.

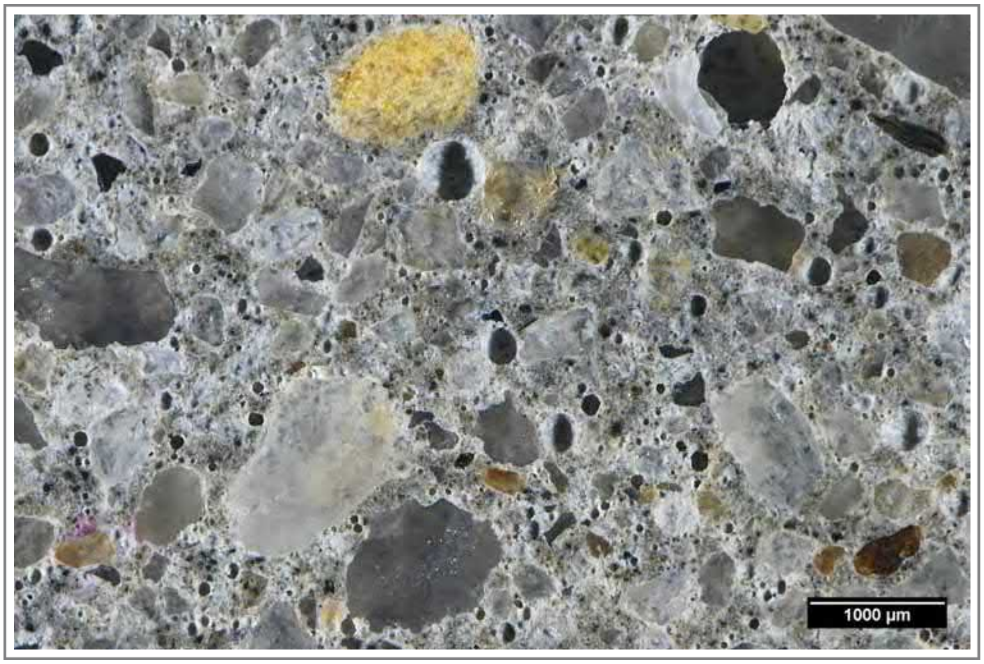


Figure B9. Reflected light photomicrograph of the polished surface showing detail of the fine aggregate.

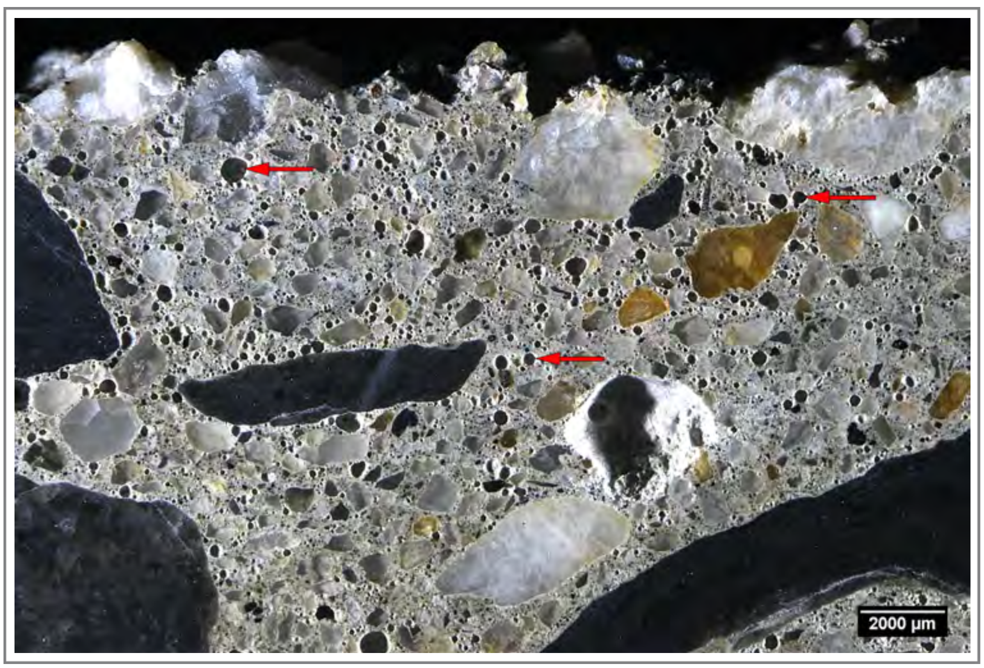
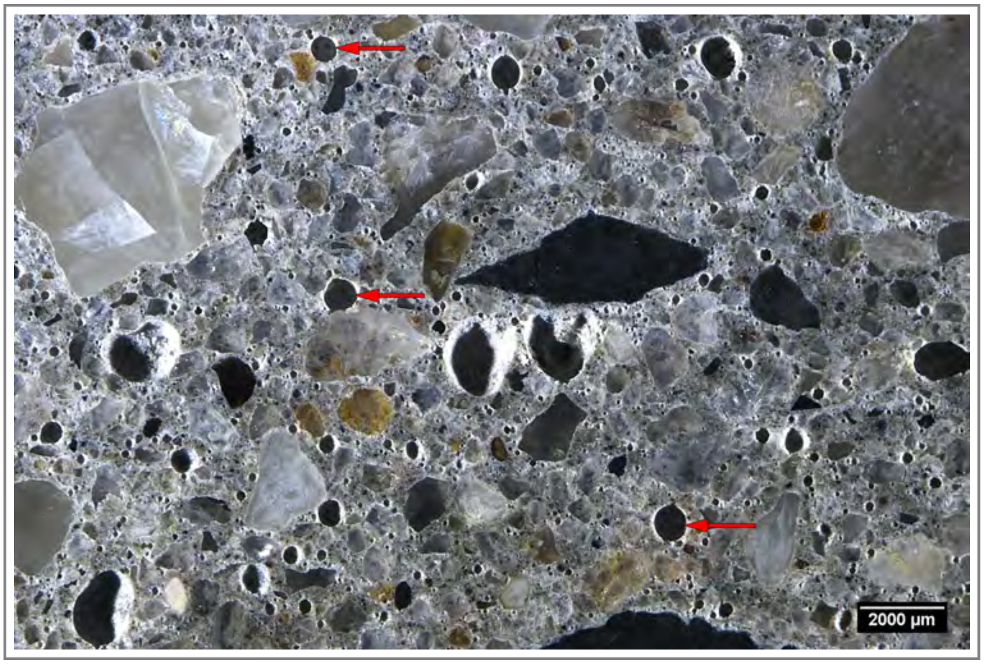
(a)


Figure B10. Images showing detail of voids within the core. (a) Reflected light photomicrograph showing detail of voids (red arrows) in the top portion of the core.



(b)

Figure B10 (cont'd). Images showing detail of voids within the core. (b) Reflected light photomicrograph showing detail of voids (red arrows) in the middle of the core.

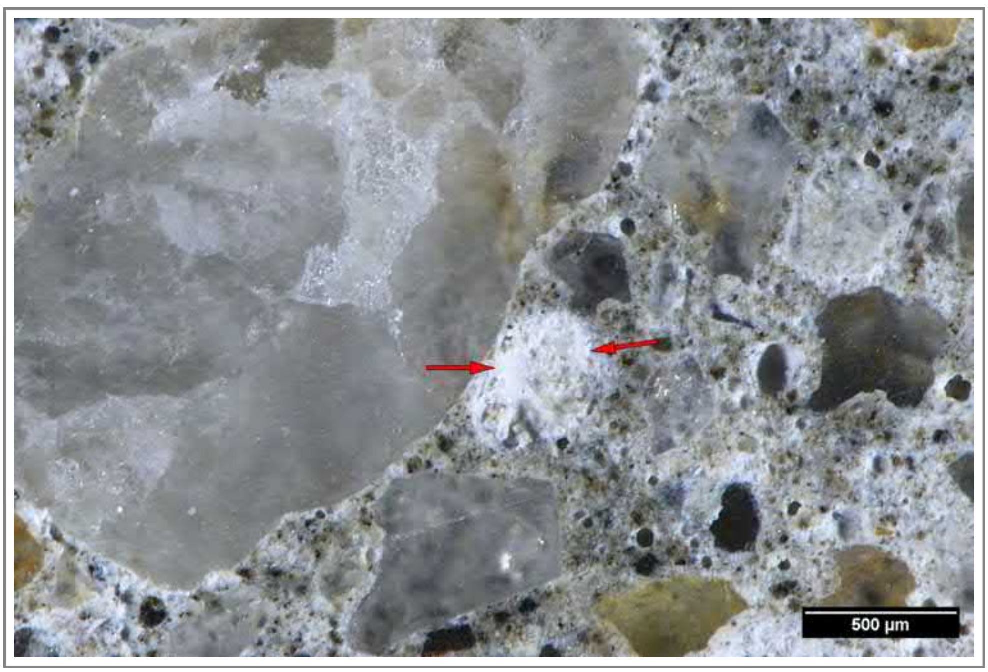


Figure B11. Reflected light photomicrograph of the polished surface showing ettringite (red arrows) in a void within the core.

(a)

(b)

Figure B12. Photographs showing (a) overview of phenolphthalein-stained cross-sectional surface of the core, and (b) detail of stained surface at the top of the core. The yellow scale in (a) is ~150 mm (6 in.) long; the small and large divisions are in centimeters and inches, respectively. The scale in (b) shows millimeter increments.

1. RECEIVED CONDITION	
ORIENTATION & DIMENSIONS	Sample is a vertical core measuring ~70 mm (2 ¾ in.) in diameter and ~145 mm (5 ¾ in.) in length (**Figure C1**).
SURFACES	The top surface is a worn concrete surface that exhibits exposed coarse aggregate and fine aggregate particles in high relief, and the bottom surface is a rough, uneven, fractured surface (**Figure C1**, **Figure C2**).
GENERAL CONDITION	The core was received intact in one piece (**Figure C1, Figure C3**).

2. EMBEDDED OBJECTS	
GENERAL	None present.

3. CRACKING	
MACROSCOPIC	Two sub-vertical ~150 µm (6 mil) wide cracks are present in the top 12 mm (½ in.) and 50 mm (2 in.) of the core and pass around aggregate particles (**Figure C4**).
MICROSCOPIC	Several randomly-oriented 10-25 µm (0.4-1 mil) wide microcracks are present in the top ~2 mm (80 mil). Few sub-vertical to diagonal ~25-75 µm (1-3 mil) wide microcracks are present in the top 1 mm (40 mil) of the core and pass around aggregate particles. Few randomly-oriented ~25-75 µm (1-3 mil) microcracks cut from coarse aggregate particles through the paste for lengths of up to 5 mm (200 mil) beyond aggregate particles; ASR gel is present within microcracks. See **Figure C5**.

4. PASTE OBSERVATIONS	
POLISHED SURFACE	Paste in the top 12 mm (½ in.) is locally light beige; remainder of paste is light gray (Munsell Soil Color GLEY 1 7/N) (**Figure C6**). Paste throughout the core is hard (Mohs 3.5-4). The paste has a smooth texture and sub-vitreous luster.
FRESH FRACTURE	Freshly fractured surfaces show same coloration and luster, and exhibit a moderately weak paste-aggregate bond such that the concrete fractures around ~75% of coarse aggregate particles when struck with a geology hammer in the petrographic laboratory (**Figure C7**).
THIN SECTION	The paste contains hydrated portland cement with no supplemental cementitious materials (**Figure C8**). The amount of observed residual portland cement is estimated at 10-15% by volume of paste. Cement hydration appears normal. Calcium hydroxide is medium to coarse grained and the observed amount is estimated at 2-7% by volume of paste. Limestone fines are common in the paste.
ESTIMATED W/C	The paste in the body of the core exhibits moderately low capillary porosity and the w/c is estimated at ~0.40 ± 0.05 (**Figure C9**).

5. COARSE AGGREGATE

PHYSICAL PROPERTIES	The coarse aggregate is a crushed carbonate rock with a 19 mm (¾ in.) nominal top size (**Figure C10**). The rocks are hard and competent. The particles are equant to elongated in shape with angular to sub-angular edges and rough surfaces. Aggregate distribution is somewhat non-uniform and gradation is fairly uneven with a low volume of intermediate sized particles. No aggregate segregation is observed.
ROCK TYPES	The coarse aggregate is carbonate in composition and consists of limestone. Some particles exhibit minor to trace amounts of quartz, chert, and/or pyrite (**Figure C11**). Particles containing siliceous material (quartz, chert) are potentially susceptible to alkali-silica reaction (ASR). No particles are potentially susceptible to alkali-carbonate reaction (ACR); carbonate particles do not contain dolomite or textural characteristics typical of potentially reactive aggregate.
OTHER FEATURES	Evidence of ASR is present in the form of trace ASR gel in rare microcracks extending outwardly from reactive coarse aggregate particles and ASR gel lining to filling rare voids adjacent to reactive coarse aggregate particles. No evidence of ACR is observed. No deleterious coatings or encrustation are observed. Rare low w/c coatings are observed (**Figure C12**).

6. FINE AGGREGATE

PHYSICAL PROPERTIES	The fine aggregate is a natural siliceous sand (**Figure C13**). Particles are hard and competent. The particles are equant in shape with sub-rounded to sub-angular edges. Aggregate gradation is fairly uniform and gradation is fairly even.
ROCK TYPES	The natural sand is siliceous in composition and consists predominately of quartz with minor amounts of quartzite, feldspar, granitic rocks, mica (muscovite and biotite), and chert with trace amounts of other rock and mineral particles. Quartz, quartzite, granitic rocks and chert are potentially susceptible to ASR. No particles are potentially susceptible to ACR.
OTHER FEATURES	No evidence of ASR or ACR is observed. No deleterious coatings or encrustation are observed. No low w/c mortar coatings are observed.

7. VOIDS

VOID SYSTEM	The concrete is air-entrained and has an estimated 6-7% total air content. Several spherical voids are observed throughout the depth of the core (**Figure C14**). Few entrapped voids are occasionally present throughout the core. The concrete is well consolidated with no notably large entrapped voids. Air void clustering is observed along the boundaries of coarse aggregate particles. Gaps between coarse aggregate and paste is observed in regions of air void clustering.
VOID FILLINGS	Ettringite occasionally lines voids throughout the core (**Figure C15**).

8. SECONDARY DEPOSITS

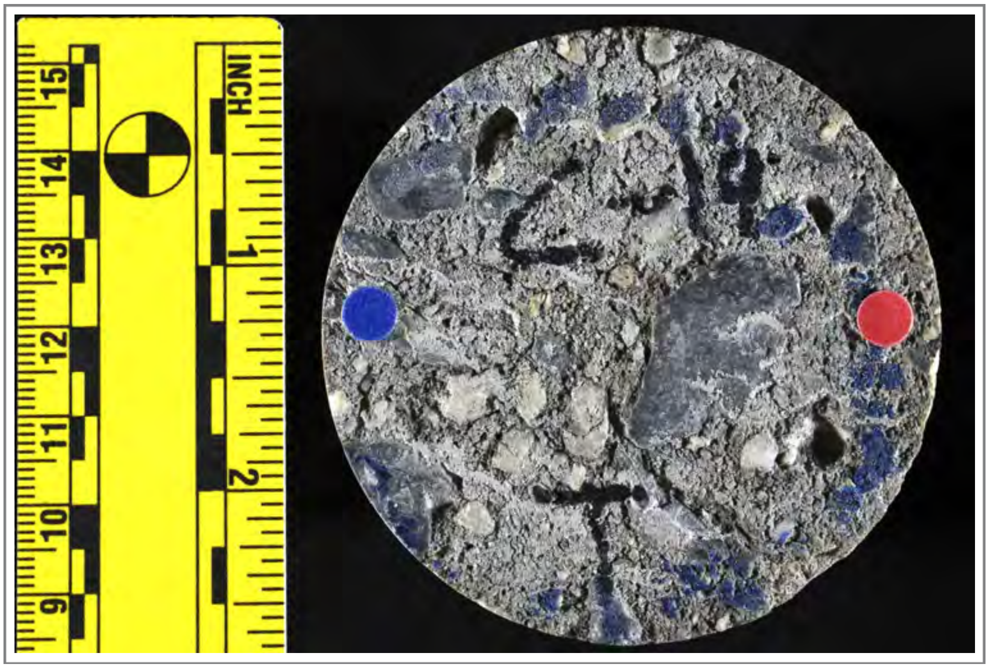
PHENOLPHTHALEIN	The paste is carbonated in the top 1 mm (40 mil) with locally deeper carbonation along sub-vertical cracks and microcracks (**Figure C16**). Phenolphthalein staining was applied to a freshly saw-cut cross-sectional surface of the core to determine general depth of paste carbonation and depth of paste carbonation was confirmed in thin section.
SECONDARY DEPOSITS	Other than ettringite in voids and ASR gel in microcracks and voids, no additional secondary deposits are observed.

FIGURES

(a)

(b)

Figure C1. Photographs of the core in as-received condition showing (a) an oblique view of the top surface and side of the core with identification labels and (b) the side of the core. The yellow scale is ~150 mm (6 in.) long; the small and large divisions are in centimeters and inches, respectively.



(c)

(d)

Figure C1 (cont'd). Photographs of the core in as-received condition showing (c) top surface of the core and (d) the bottom surface of the core. The red and blue dots in (c) show the orientation of the saw cuts used to prepare the core. The yellow scale is ~150 mm (6 in.) long; the small and large divisions are in centimeters and inches, respectively.

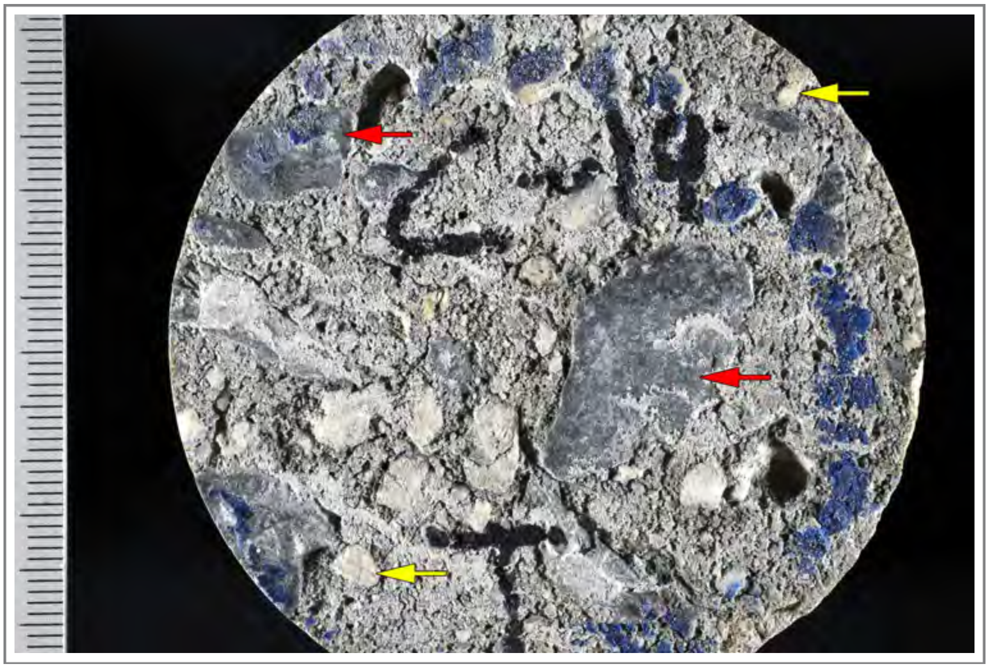


Figure C2. Photograph of the as-received condition of the top surface of the core. Red arrows indicate exposed coarse aggregate particles. Scale shows millimeter increments.

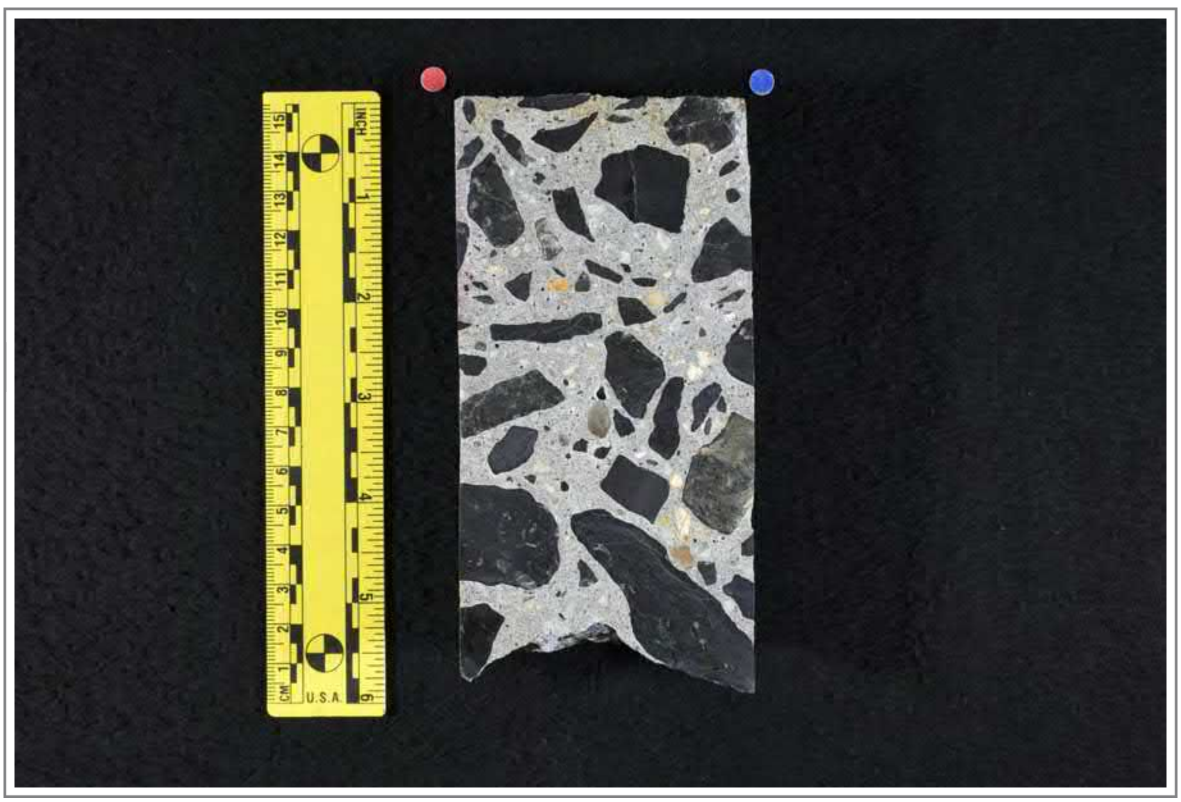
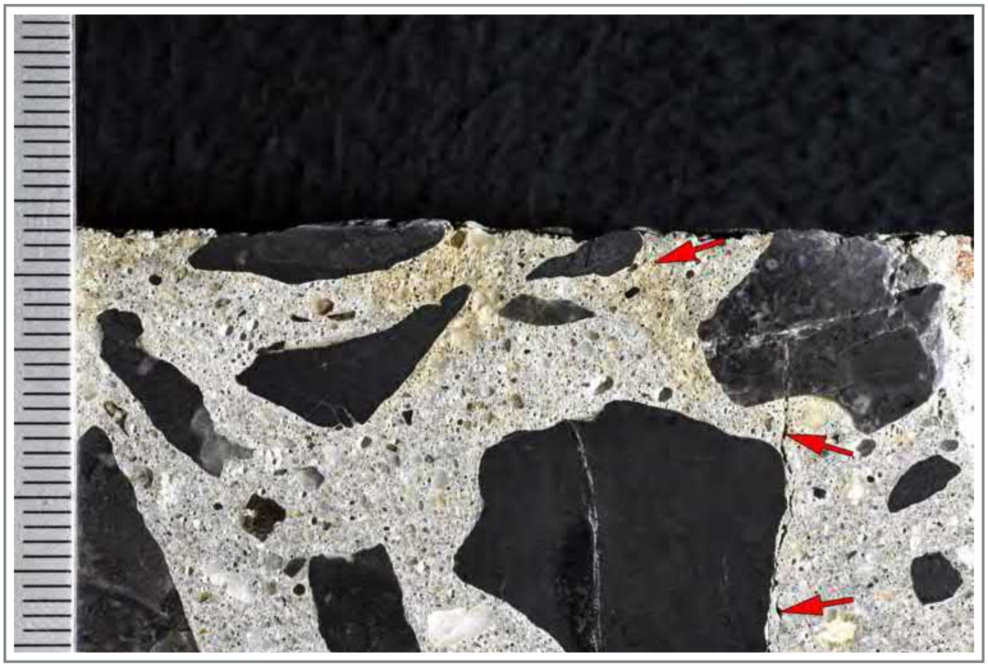
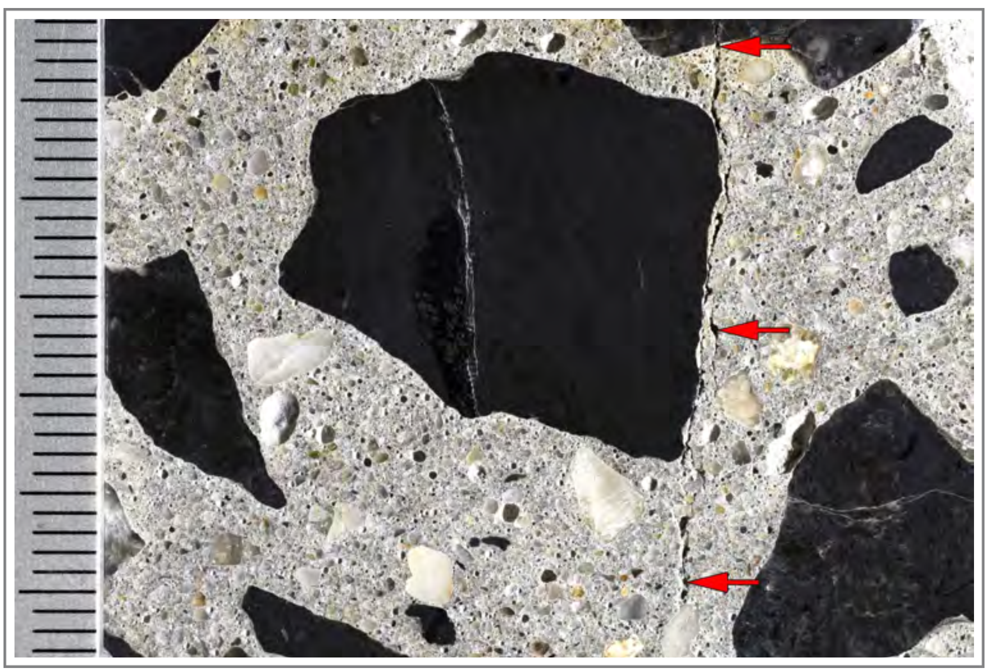


Figure C3. Photograph showing the polished surface of the slab prepared from the core. The red and blue dots show the orientation of the saw cuts used to prepare the core. The yellow scale is ~150 mm (6 in.) long; the small and large divisions are in centimeters and inches, respectively.

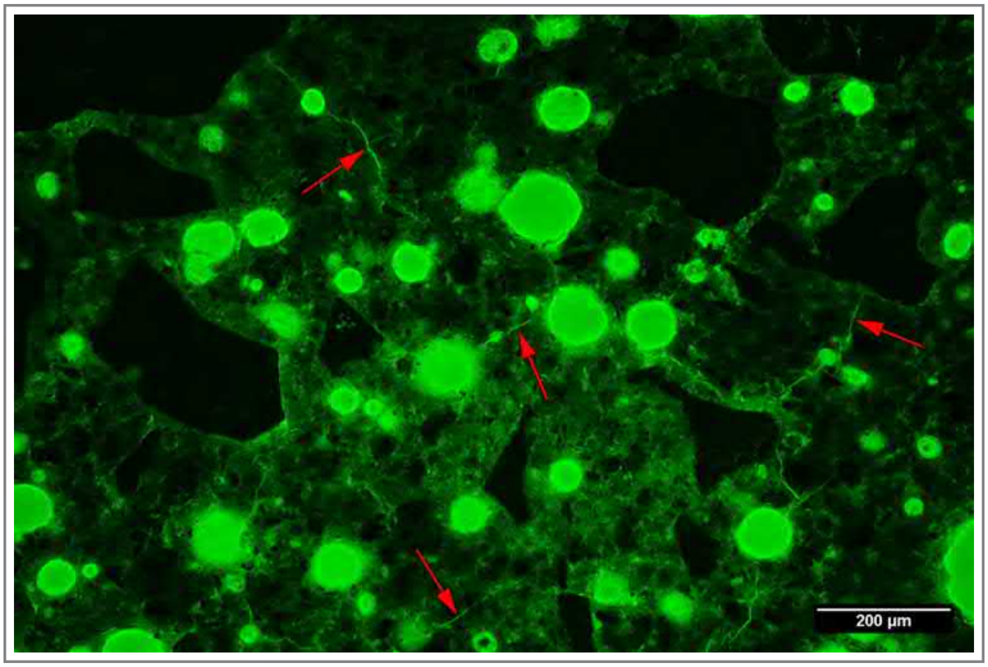


(a)

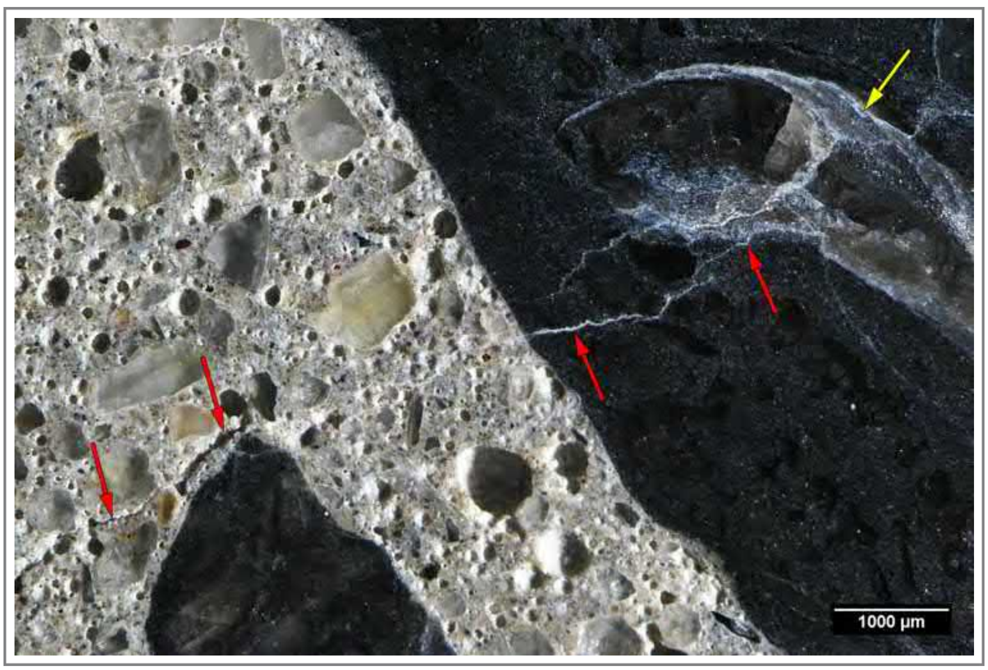


(b)

Figure C4. Photographs showing detail of sub-vertical crack (red arrows) in the top ~50 mm (2 in.) of the core. Scale in both images shows millimeter increments.



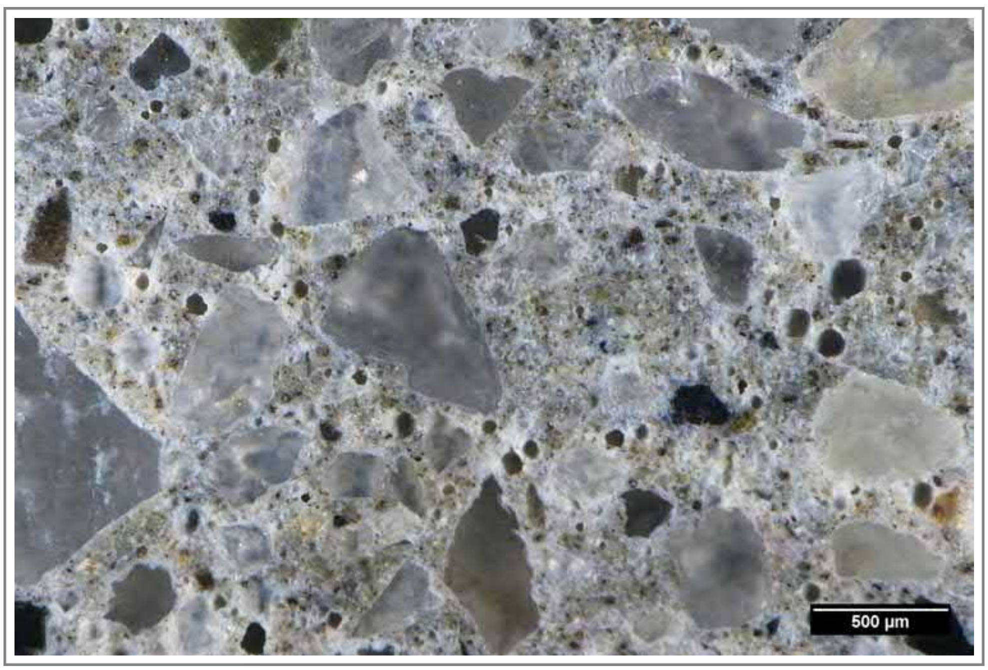
(a)



(b)

Figure C5. Images showing examples of microcracks in the core. (a) Transmitted fluorescent light thin section photomicrograph showing fine, randomly-oriented microcracks (red arrows) in the near-surface region of the core. (b) Reflected light photomicrograph showing detail of microcrack (red arrows) cutting from cherty portion of coarse aggregate particle into the paste.

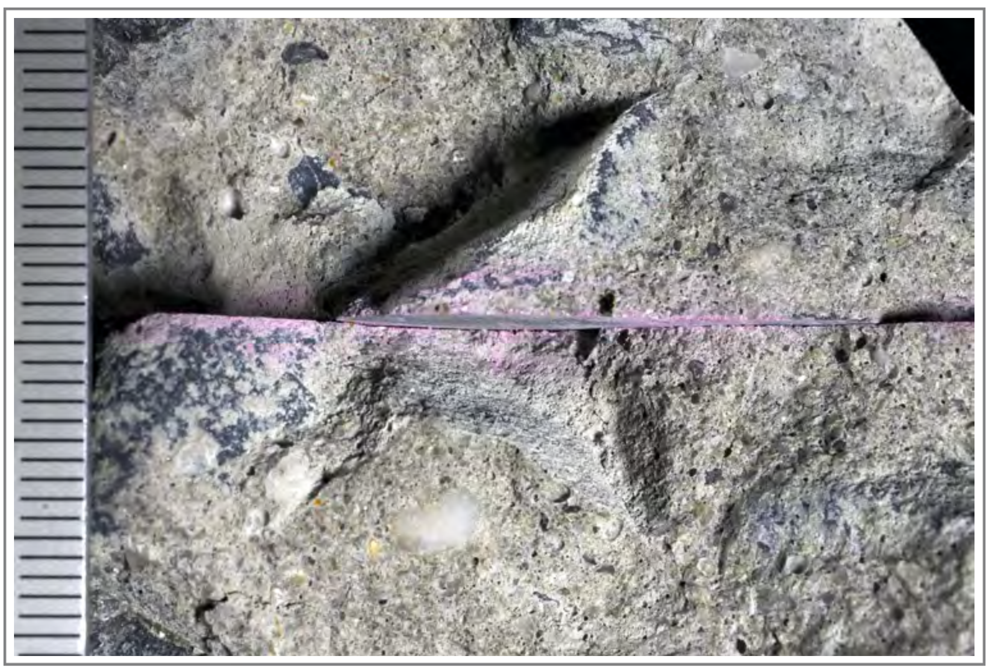
(a)



(b)

Figure C6. Images showing detail of the paste. (a) Photograph showing paste in the near-surface region of the core. Scale shows millimeter increments. (b) Reflected light photomicrograph showing paste detail in the body of the core.

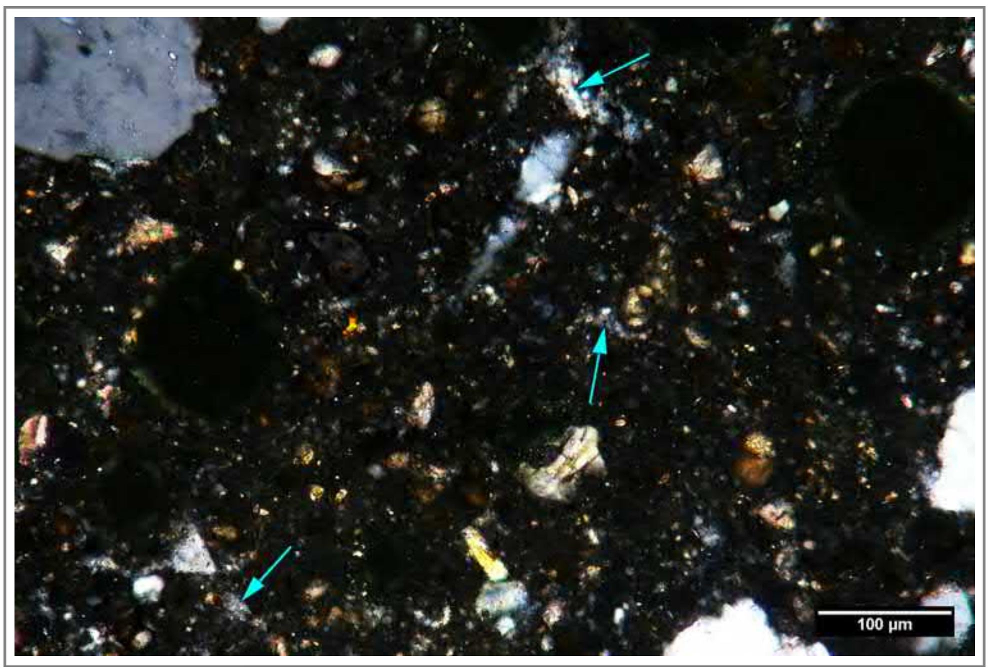
(a)



(b)

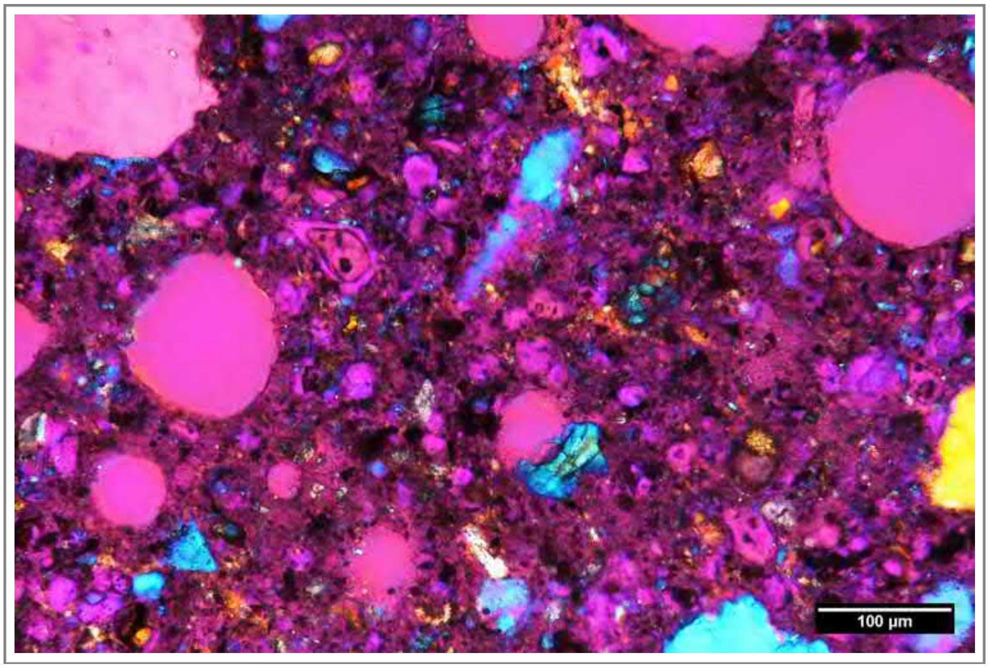
Figure C7. Photographs showing (a) overview and (b) detail of freshly fractured concrete surfaces. Scale in both images shows millimeter increments.

(a)



(b)

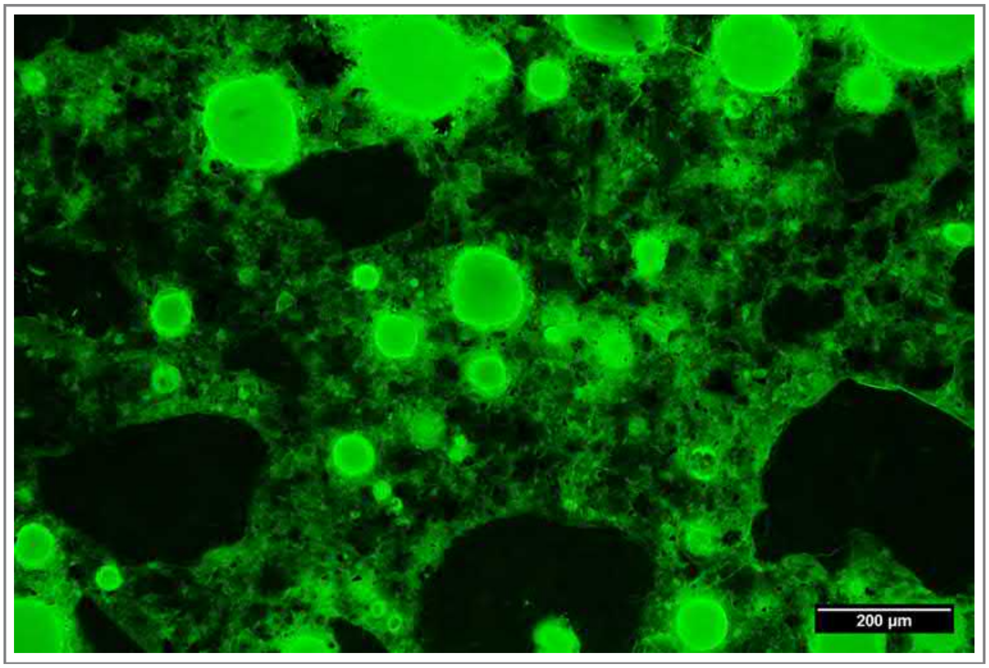
Figure C8. Transmitted light photomicrographs of thin section showing detail of paste in the body of the core in (a) plane-polarized light and (b) cross-polarized light. Red arrows in (a) indicate portland cement particles. Blue arrows in (b) indicate calcium hydroxide.



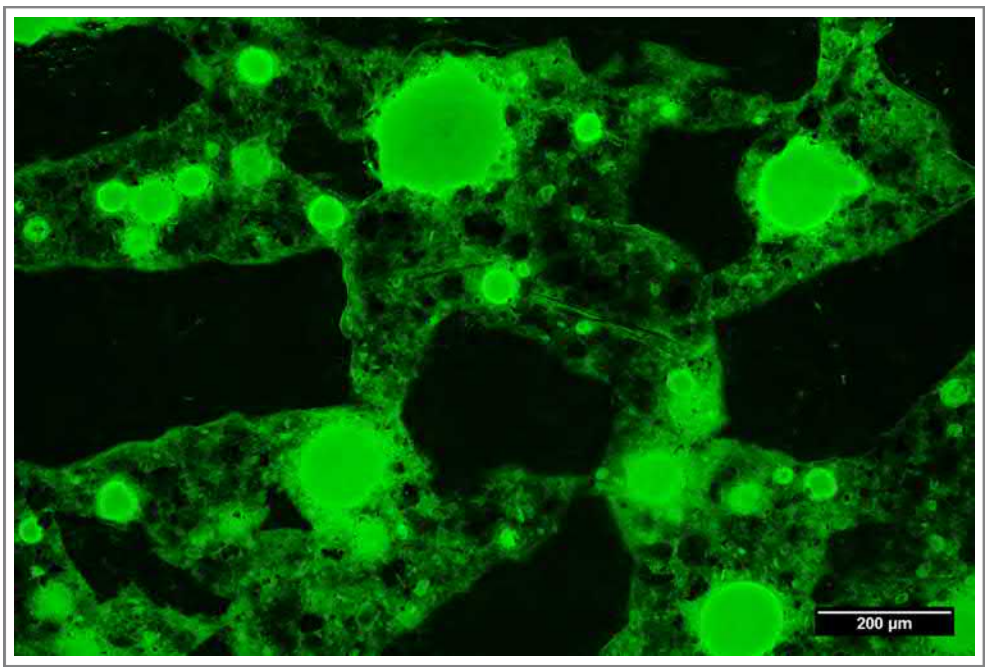
(c)

(d)

Figure C8 (cont'd). Transmitted light photomicrographs of thin section showing detail of paste in the body of the core in (c) cross-polarized light with the gypsum plate inserted and (d) cross-polarized light with the quarter wave plate inserted.



(a)



(b)

Figure C9. Fluorescent light photomicrographs showing capillary porosity of the paste in two different regions of the body of the core. Bright circular areas are voids that have 100% porosity and the black regions are aggregate particles with effectively zero porosity. The variations in green tone between these two end-members reflect variations in the capillary porosity of the paste.

Figure C10. Photograph of the polished surface showing detail of the coarse aggregate. Scale shows millimeter increments.

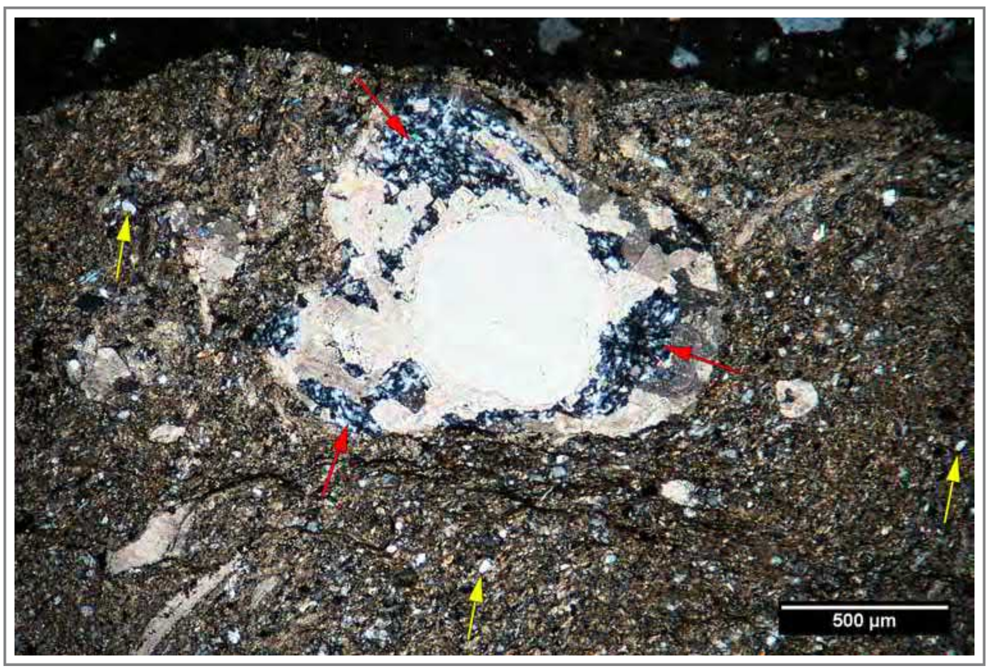


Figure C11. Transmitted cross-polarized light thin section photomicrograph showing chert (red arrows) and quartz grains (yellow arrows) within a siliceous limestone coarse aggregate particle.

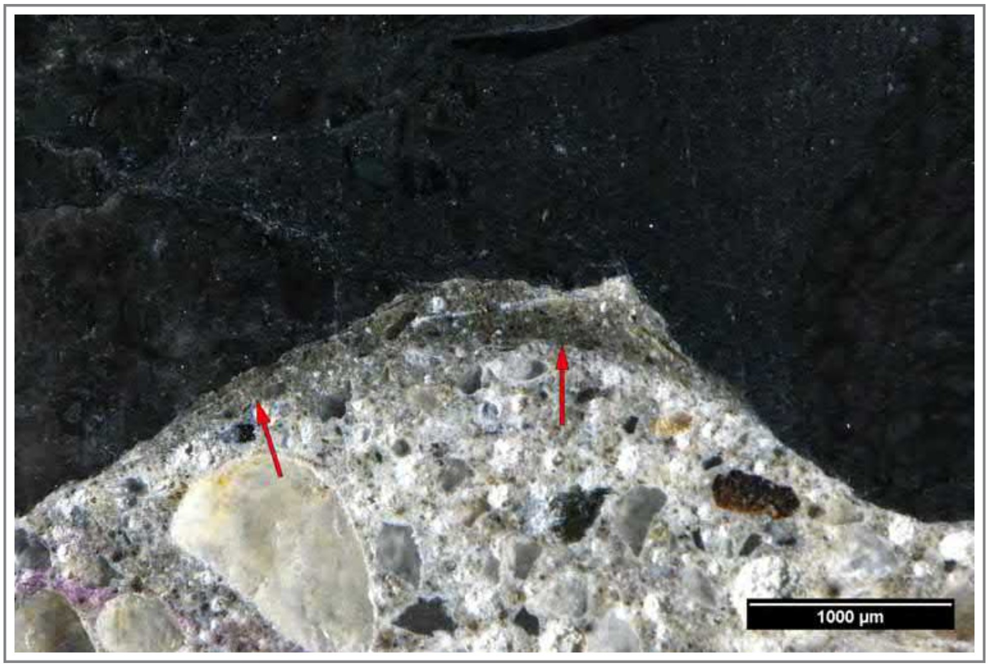


Figure C12. Reflected light photomicrograph of the polished surface showing low w/cm mortar coating (red arrows) along a coarse aggregate particle.

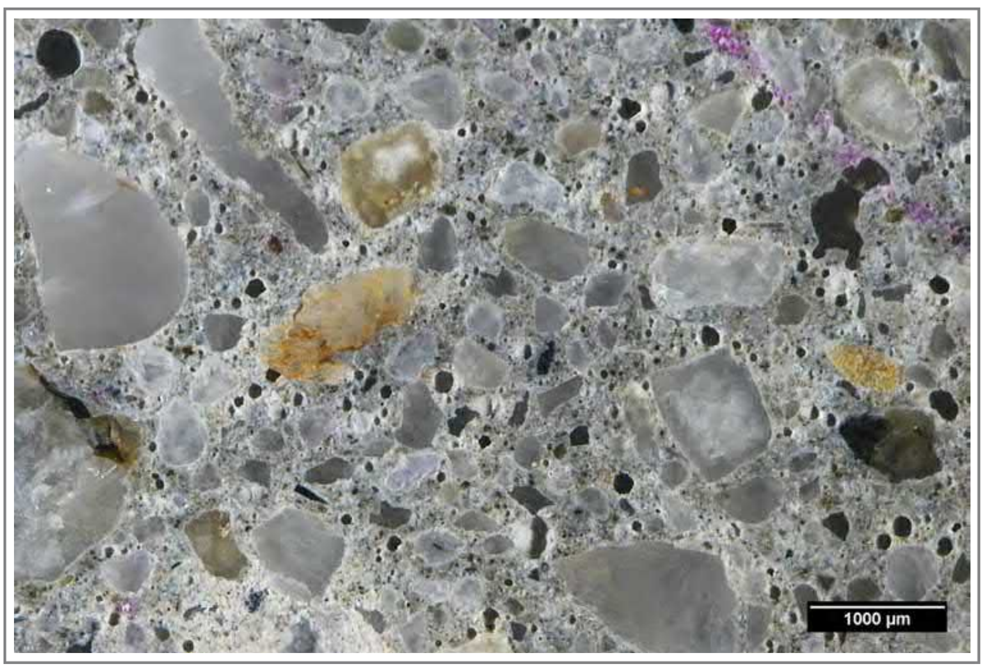
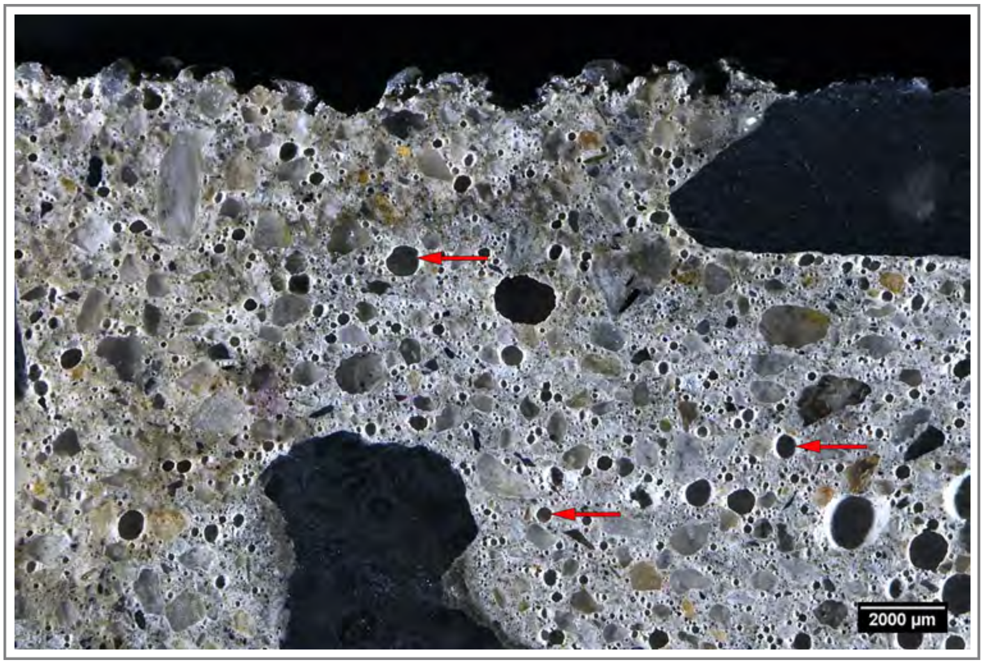
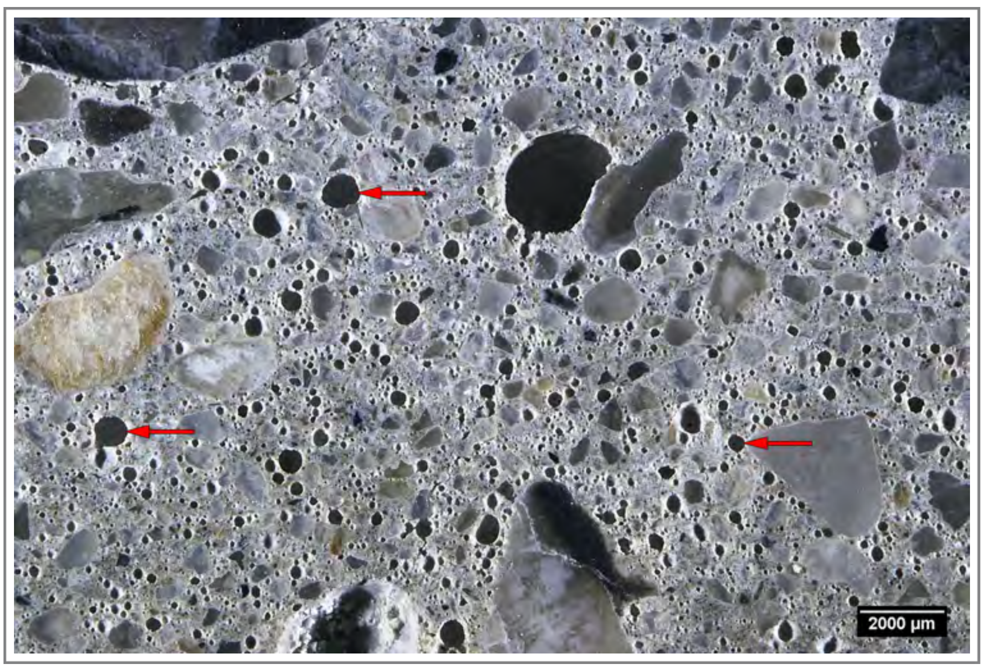


Figure C13. Reflected light photomicrograph of the polished surface showing detail of the fine aggregate.

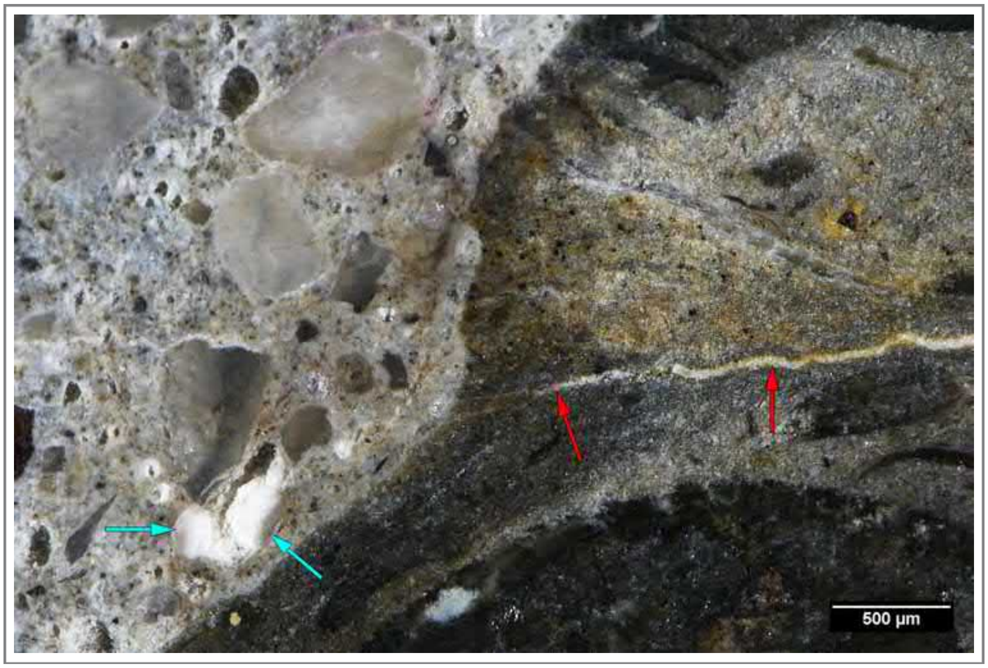


(a)

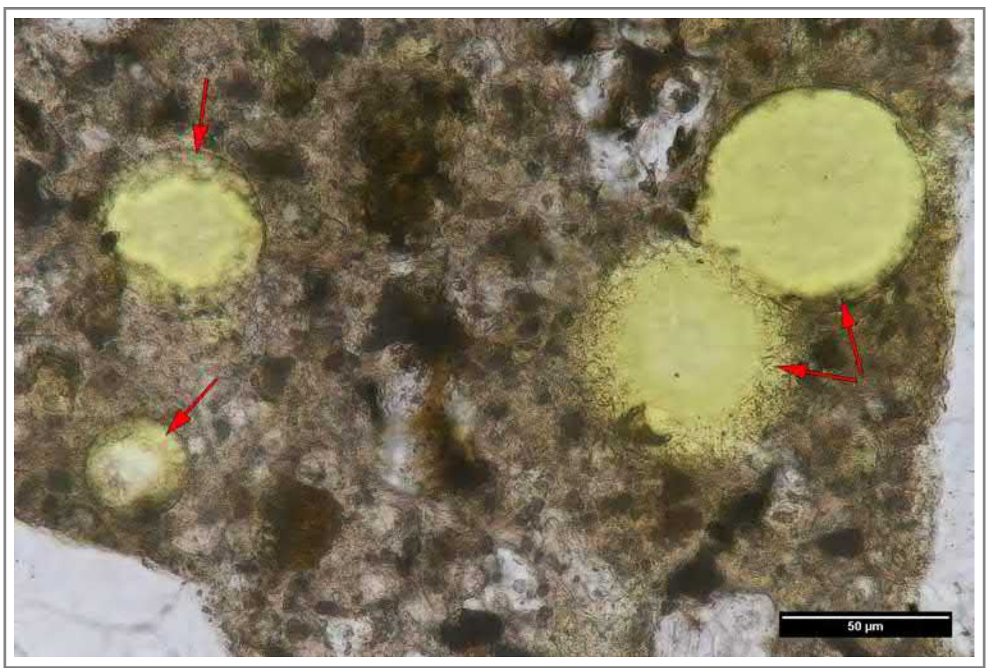


(b)

Figure C14. Images showing detail of voids within the core. (a) Reflected light photomicrograph showing detail of voids (red arrows) in the top portion of the core. (b) Reflected light photomicrograph showing detail of voids (red arrows) in the middle of the core. (c) Reflected light photomicrograph showing detail of air void clustering (encircled red) along coarse aggregate particle and gaps between aggregate and paste (yellow arrows).



(a)



(b)

Figure C15. Images showing secondary deposits in voids. (a) Reflected light photomicrograph of the polished surface showing ASR gel-filled microcrack (red arrows) extending through a coarse aggregate particle and ASR gel partially filling a void (blue arrows). (b) Transmitted plane-polarized light thin section photomicrograph showing ettringite (red arrows) in voids.

(a)

(b)

Figure C16. Photographs showing (a) overview of phenolphthalein-stained cross-sectional surface of the core, and (b) detail of stained surface at the top of the core. The yellow scale in (a) is ~150 mm (6 in.) long; the small and large divisions are in centimeters and inches, respectively. The scale in (b) shows millimeter increments.

1. RECEIVED CONDITION	
ORIENTATION & DIMENSIONS	Sample is a vertical core measuring ~70 mm (2 ¾ in.) in diameter and ~150 mm (5 ⅞ in.) in length (**Figure D1**).
SURFACES	The top surface is a worn concrete surface that exhibits exposed coarse aggregate and fine aggregate particles in high relief, and the bottom surface is a rough, uneven, fractured surface (**Figure D1**, **Figure D2**).
GENERAL CONDITION	The core was received intact in one piece (**Figure D1, Figure D3**).

2. EMBEDDED OBJECTS	
GENERAL	None present.

3. CRACKING	
MACROSCOPIC	None present.
MICROSCOPIC	Few sub-vertical to diagonal ~25-75 µm (1-3 mil) wide microcracks are present in the top 5 mm (200 mil or ¼ in.) of the core and pass around aggregate particles (**Figure D4**).

4. PASTE OBSERVATIONS	
POLISHED SURFACE	Paste in the top 4 mm (¼ in.) is locally light beige; remainder of paste is light gray (Munsell Soil Color GLEY 1 7/N) (**Figure D5**). Paste throughout the core is hard (Mohs 3.5-4). The paste has a smooth texture and sub-vitreous luster.
FRESH FRACTURE	Freshly fractured surfaces show same coloration and luster, and exhibit a moderately weak paste-aggregate bond such that the concrete fractures around ~75% of coarse aggregate particles when struck with a geology hammer in the petrographic laboratory (**Figure D6**).
THIN SECTION	Thin section evaluation was not performed.
ESTIMATED W/C	Thin section evaluation was not performed; w/c was not estimated.

5. COARSE AGGREGATE	
PHYSICAL PROPERTIES	The coarse aggregate is a crushed carbonate rock with a 19 mm (¾ in.) nominal top size (**Figure D7**). The rocks are hard and competent. The particles are equant to elongated in shape with angular to sub-angular edges and rough surfaces. Aggregate distribution is fairy uniform and gradation is fairly uneven with a low volume of intermediate sized particles. No aggregate segregation is observed.
ROCK TYPES	The coarse aggregate is carbonate in composition and consists of limestone. Some particles exhibit minor to trace amounts of quartz, chert, and/or pyrite. Particles containing siliceous material (quartz, chert) are potentially susceptible to alkali-silica reaction (ASR). No particles are potentially susceptible to alkali-carbonate reaction (ACR); carbonate particles do not contain dolomite or textural characteristics typical of potentially reactive aggregate.
OTHER FEATURES	No evidence of ASR or ACR is observed. No deleterious coatings or encrustation are observed. Rare low w/c mortar coatings are observed (**Figure D8**).

6. FINE AGGREGATE	
PHYSICAL PROPERTIES	The fine aggregate is a natural siliceous sand (**Figure D9**). Particles are hard and competent. The particles are equant in shape with sub-rounded to sub-angular edges. Aggregate gradation is fairly uniform and gradation is fairly even.
ROCK TYPES	The natural sand is siliceous in composition and consists predominately of quartz with minor amounts of quartzite, feldspar, granitic rocks, mica (muscovite and biotite), and chert with trace amounts of other rock and mineral particles. Quartz, quartzite, granitic rocks and chert are potentially susceptible to ASR. No particles are potentially susceptible to ACR.
OTHER FEATURES	No evidence of ASR or ACR is observed. No deleterious coatings or encrustation are observed. No low w/c mortar coatings are observed.

7. VOIDS	
VOID SYSTEM	The concrete is air-entrained and has an estimated 6-7% total air content. Several spherical voids are observed throughout the depth of the core (**Figure D10**). Few entrapped voids are occasionally present throughout the core. The concrete is well consolidated with no notably large entrapped voids.
VOID FILLINGS	Ettringite occasionally lines voids throughout the core (**Figure D11**).

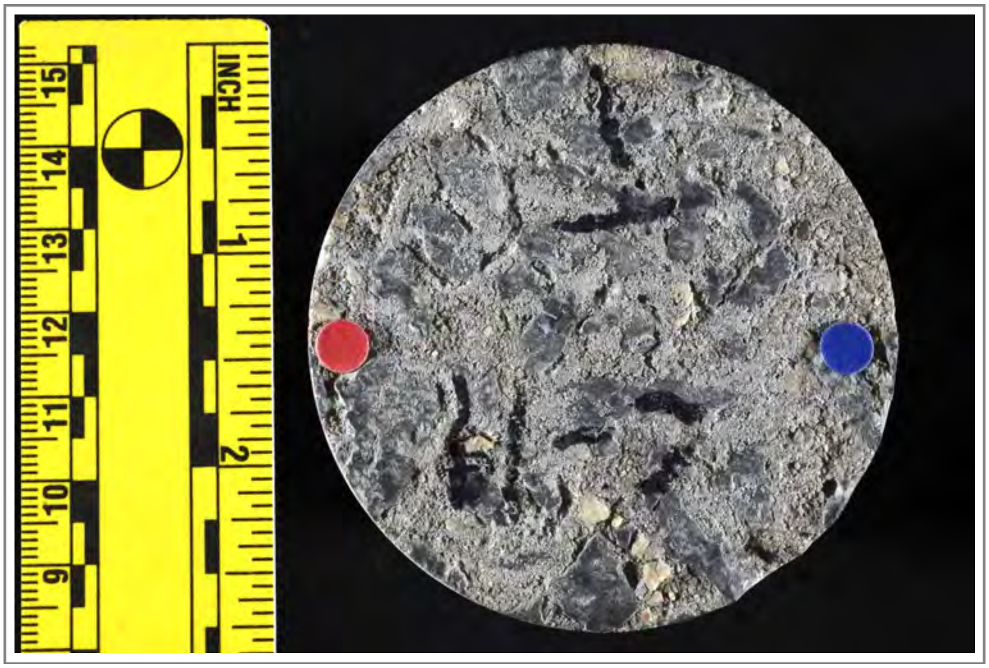
8. SECONDARY DEPOSITS	
PHENOLPHTHALEIN	The paste is carbonated in the top 1 mm (40 mil) with locally deeper carbonation along sub-vertical microcracks (**Figure D12**). Phenolphthalein staining was applied to a freshly saw-cut cross-sectional surface of the core to determine general depth of paste carbonation.
SECONDARY DEPOSITS	Other than ettringite in voids, no additional secondary deposits are observed.

FIGURES

(a)

(b)

Figure D1. Photographs of the core in as-received condition showing (a) an oblique view of the top surface and side of the core with identification labels and (b) the side of the core. The yellow scale is ~150 mm (6 in.) long; the small and large divisions are in centimeters and inches, respectively.

(c) 

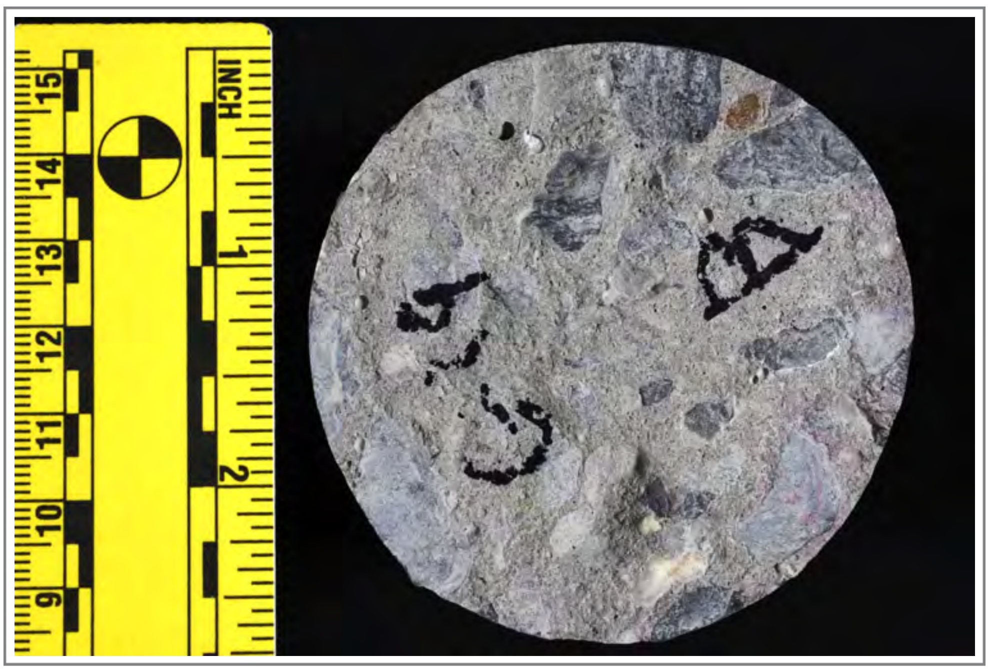
(d) 

Figure D1 (cont'd). Photographs of the core in as-received condition showing (c) top surface of the core and (d) the bottom surface of the core. The red and blue dots in (c) show the orientation of the saw cuts used to prepare the core. The yellow scale is ~150 mm (6 in.) long; the small and large divisions are in centimeters and inches, respectively.

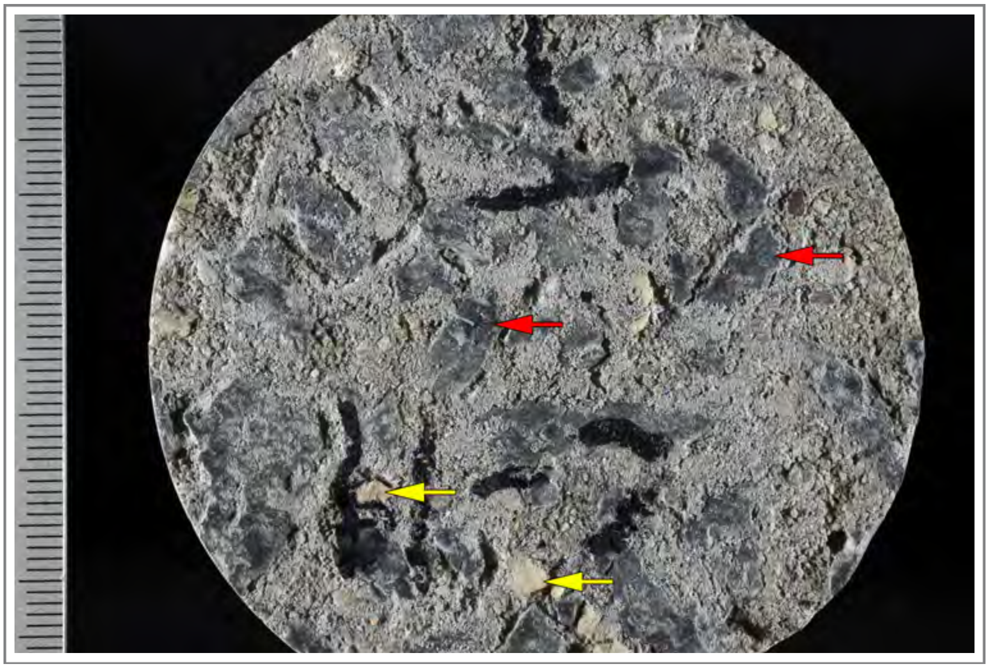


Figure D2. Photograph of the as-received condition of the top surface of the core. Red and yellow arrows indicate exposed coarse and fine aggregate particles, respectively. Scale shows millimeter increments.

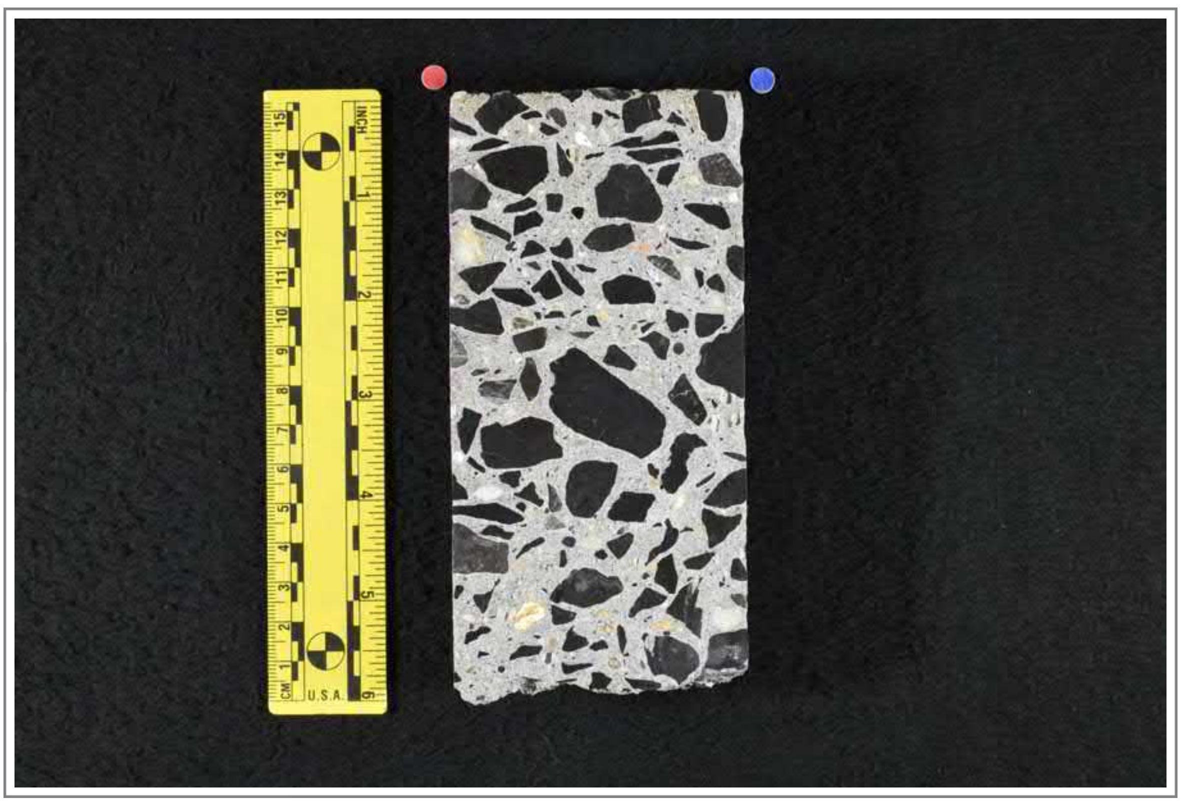


Figure D3. Photograph showing the polished surface of the slab prepared from the core. The red and blue dots show the orientation of the saw cuts used to prepare the core. The yellow scale is ~150 mm (6 in.) long; the small and large divisions are in centimeters and inches, respectively.

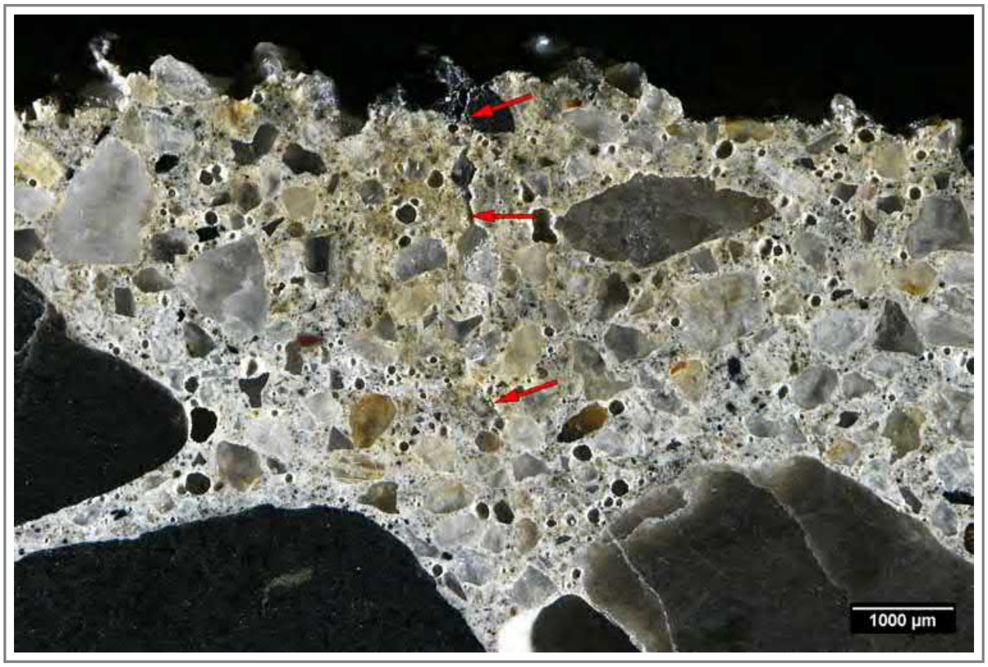
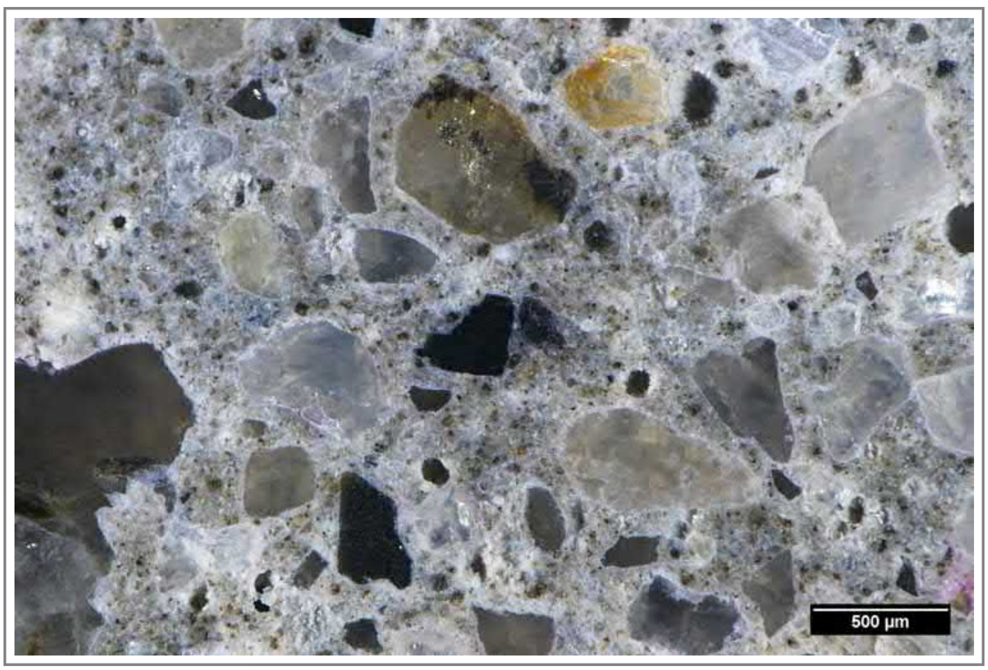


Figure D4. Reflected light photomicrograph showing detail of a sub-vertical microcrack (red arrows) in the near-surface region of the paste.

(a)



(b)

Figure D5. Images showing detail of the paste. (a) Photograph showing paste in the near-surface region of the core. Scale shows millimeter increments. (b) Reflected light photomicrograph showing paste detail in the body of the core.

(a)

(b)

Figure D6. Photographs showing (a) overview and (b) detail of freshly fractured concrete surfaces. Scale in both images shows millimeter increments.

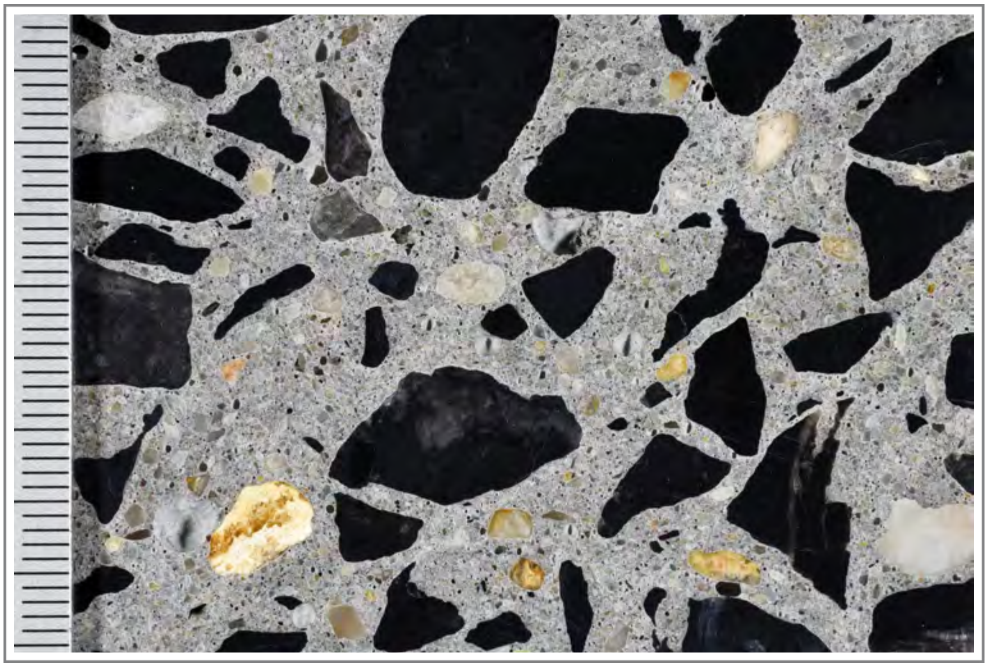


Figure D7. Photograph of the polished surface showing detail of the coarse aggregate. Scale shows millimeter increments.

Figure D8. Reflected light photomicrograph of the polished surface showing low w/cm mortar coating (red arrows) along a coarse aggregate particle.

Figure D9. Reflected light photomicrograph of the polished surface showing detail of the fine aggregate.

(a)

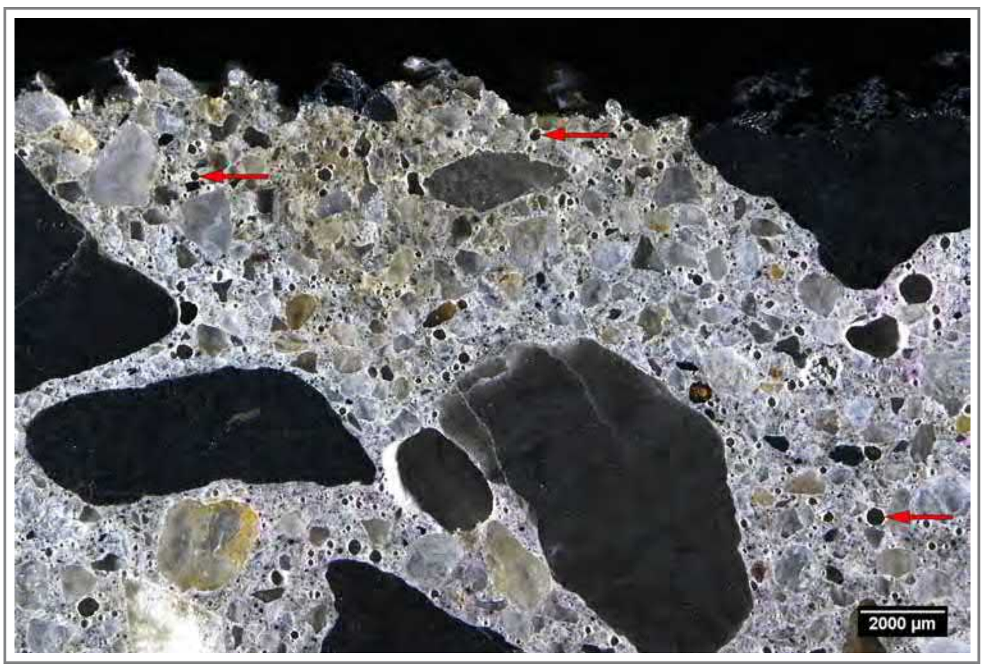


Figure D10. Images showing detail of voids within the core. (a) Reflected light photomicrograph showing detail of voids (red arrows) in the top portion of the core.

(b)

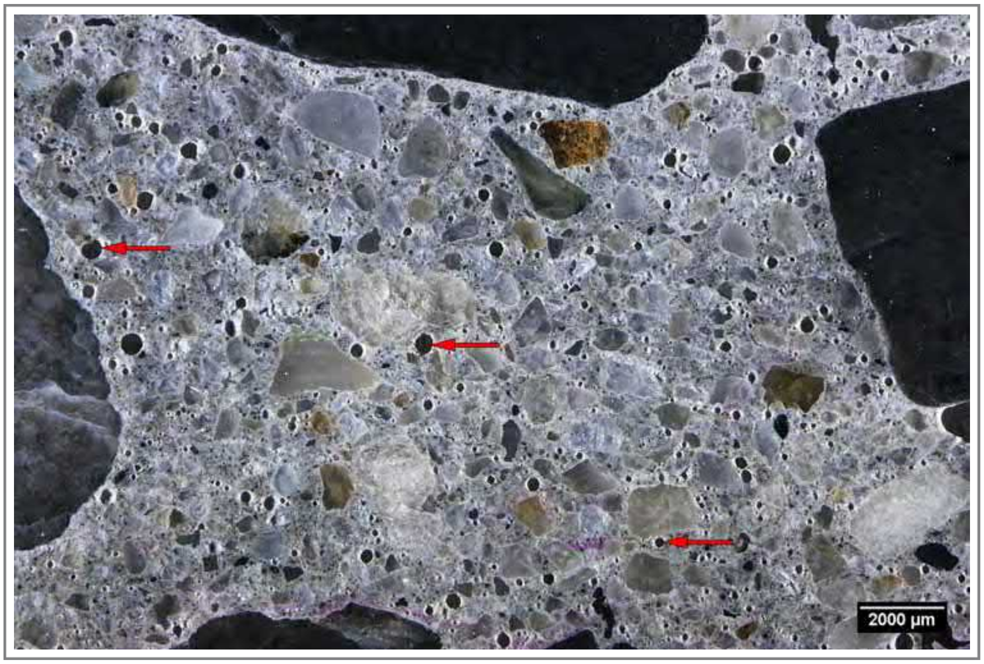


Figure D10 (cont'd). Images showing detail of voids within the core. (b) Reflected light photomicrograph showing detail of voids (red arrows) in the middle of the core.

Figure D11. Reflected light photomicrograph of the polished surface showing ettringite (red arrows) in several voids within the core.

(a)

(b)

Figure D12. Photographs showing (a) overview of phenolphthalein-stained cross-sectional surface of the core, and (b) detail of stained surface at the top of the core. The yellow scale in (a) is ~150 mm (6 in.) long; the small and large divisions are in centimeters and inches, respectively. The scale in (b) shows millimeter increments.

1. RECEIVED CONDITION	
ORIENTATION & DIMENSIONS	Sample is a vertical core measuring ~70 mm (2 ¾ in.) in diameter and ~140 mm (5 ½ in.) in length (**Figure E1**).
SURFACES	The top surface is a worn concrete surface that exhibits exposed coarse aggregate and fine aggregate particles in high relief, and the bottom surface is a rough, uneven, fractured surface (**Figure E1**, **Figure E2**).
GENERAL CONDITION	The core was received intact in one piece (**Figure E1, Figure E3**).

2. EMBEDDED OBJECTS	
GENERAL	None present.

3. CRACKING	
MACROSCOPIC	None present.
MICROSCOPIC	Few sub-vertical ~25-100 µm (1-4 mil) wide microcracks are present in the top 9 mm (⅜ in.) of the core and pass around aggregate particles. Few sub-vertical to diagonal ~25-75 µm (1-3 mil) wide microcracks are present in the top 1 mm (40 mil) of the core and pass around aggregate particles. Few randomly-oriented ~25-75 µm (1-3 mil) microcracks cut from coarse aggregate particles through the paste for lengths of up to 2 mm (80 mil) beyond aggregate particles; ASR gel is present within microcracks. See **Figure E4**.

4. PASTE OBSERVATIONS	
POLISHED SURFACE	Paste in the top 5 mm (¼ in.) is locally light beige; remainder of paste is light gray (Munsell Soil Color GLEY 1 7/N) (**Figure E5**). Paste throughout the core is hard (Mohs 3.5-4). The paste has a smooth texture and sub-vitreous luster.
FRESH FRACTURE	Freshly fractured surfaces show same coloration and luster, and exhibit a moderately weak paste-aggregate bond such that the concrete fractures around ~75% of coarse aggregate particles when struck with a geology hammer in the petrographic laboratory (**Figure E6**).
THIN SECTION	Thin section evaluation was not performed.
ESTIMATED W/C	Thin section evaluation was not performed; w/c was not estimated.

5. COARSE AGGREGATE	
PHYSICAL PROPERTIES	The coarse aggregate is a crushed carbonate rock with a 19 mm (¾ in.) nominal top size (**Figure E7**). The rocks are hard and competent. The particles are equant to elongated in shape with angular to sub-angular edges and rough surfaces. Aggregate distribution is somewhat non-uniform and gradation is fairly uneven with a low volume of intermediate sized particles. No aggregate segregation is observed.
ROCK TYPES	The coarse aggregate is carbonate in composition and consists of limestone. Some particles exhibit minor to trace amounts of quartz, chert, and/or pyrite. Particles containing siliceous material (quartz, chert) are potentially susceptible to alkali-silica reaction (ASR). No particles are potentially susceptible to alkali-carbonate reaction (ACR); carbonate particles do not contain dolomite or textural characteristics typical of potentially reactive aggregate.
OTHER FEATURES	Evidence of ASR is present in the form of trace ASR gel in rare microcracks extending outwardly from reactive coarse aggregate particles and ASR gel lining to filling rare voids adjacent to reactive coarse aggregate particles. No evidence of ACR is observed. No deleterious coatings or encrustation are observed. Rare low w/c coatings are observed (**Figure E8**).

6. FINE AGGREGATE	
PHYSICAL PROPERTIES	The fine aggregate is a natural siliceous sand (**Figure E9**). Particles are hard and competent. The particles are equant in shape with sub-rounded to sub-angular edges. Aggregate gradation is fairly uniform and gradation is fairly even.
ROCK TYPES	The natural sand is siliceous in composition and consists predominately of quartz with minor amounts of quartzite, feldspar, granitic rocks, mica (muscovite and biotite), and chert with trace amounts of other rock and mineral particles. Quartz, quartzite, granitic rocks and chert are potentially susceptible to ASR. No particles are potentially susceptible to ACR.
OTHER FEATURES	No evidence of ASR or ACR is observed. No deleterious coatings or encrustation are observed. No low w/c mortar coatings are observed.

7. VOIDS	
VOID SYSTEM	The concrete is air-entrained and has an estimated 6-7% total air content. Several spherical voids are observed throughout the depth of the core (**Figure E10**). Few entrapped voids are occasionally present throughout the core. The concrete is well consolidated with no notably large entrapped voids.
VOID FILLINGS	Ettringite occasionally lines voids throughout the core. ASR gel rarely lines to fill voids adjacent to reactive coarse aggregate particles throughout the core. See **Figure E11**.

8. SECONDARY DEPOSITS	
PHENOLPHTHALEIN	The paste is carbonated in the top 1 mm (40 mil) with locally deeper carbonation along sub-vertical microcracks (**Figure E12**). Phenolphthalein staining was applied to a freshly saw-cut cross-sectional surface of the core to determine general depth of paste carbonation.
SECONDARY DEPOSITS	Other than ettringite in voids and ASR gel in microcracks and voids, no additional secondary deposits are observed.

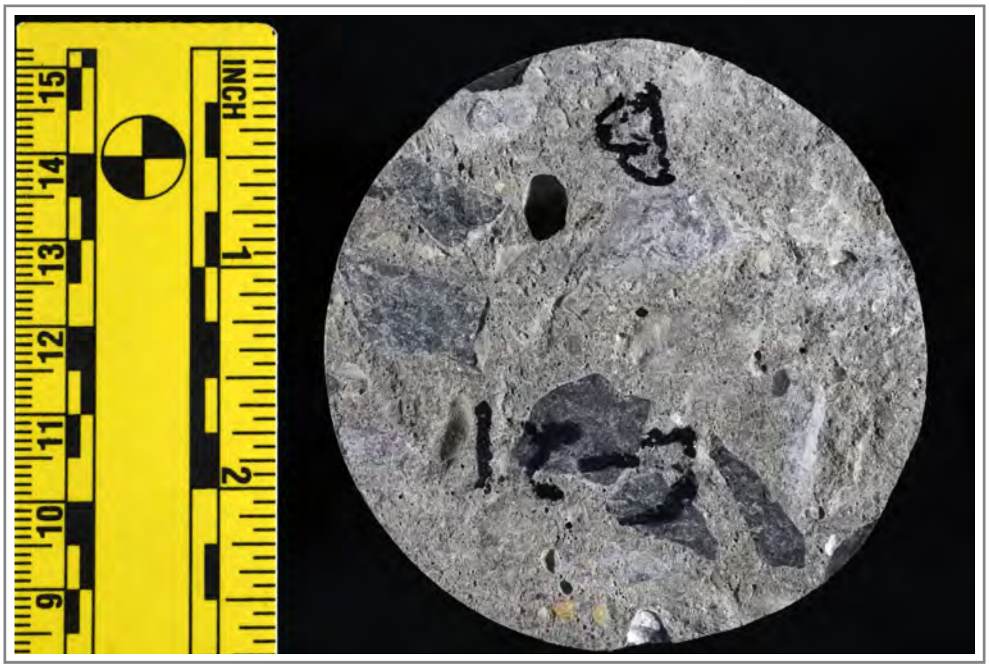
FIGURES

(a)

(b)

Figure E1. Photographs of the core in as-received condition showing (a) an oblique view of the top surface and side of the core with identification labels and (b) the side of the core. The yellow scale is ~150 mm (6 in.) long; the small and large divisions are in centimeters and inches, respectively.

(c)



(d)

Figure E1 (cont'd). Photographs of the core in as-received condition showing (c) top surface of the core and (d) the bottom surface of the core. The red and blue dots in (c) show the orientation of the saw cuts used to prepare the core. The yellow scale is ~150 mm (6 in.) long; the small and large divisions are in centimeters and inches, respectively.

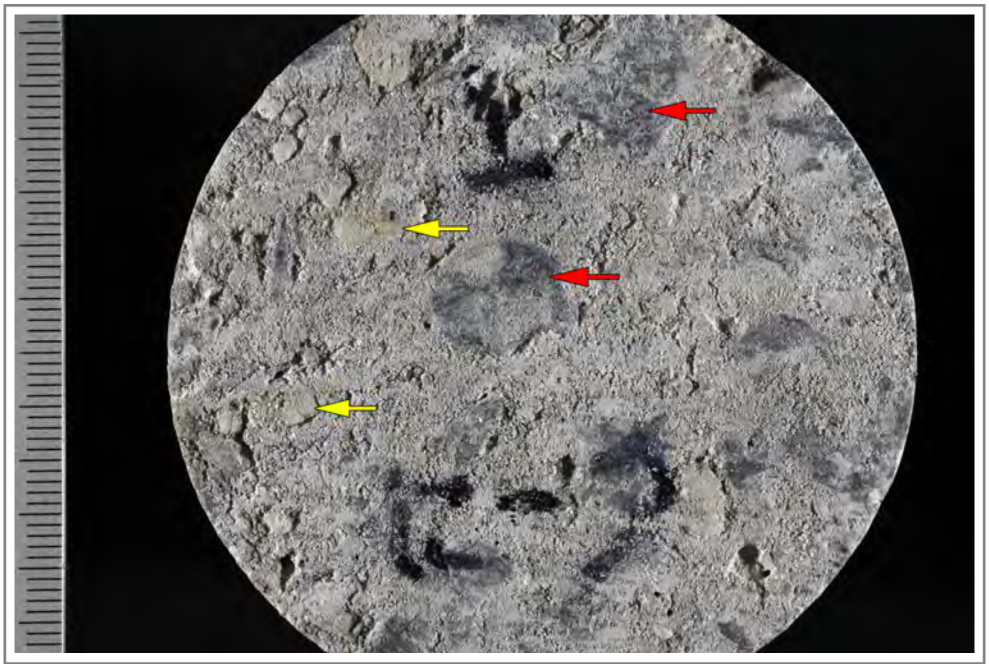
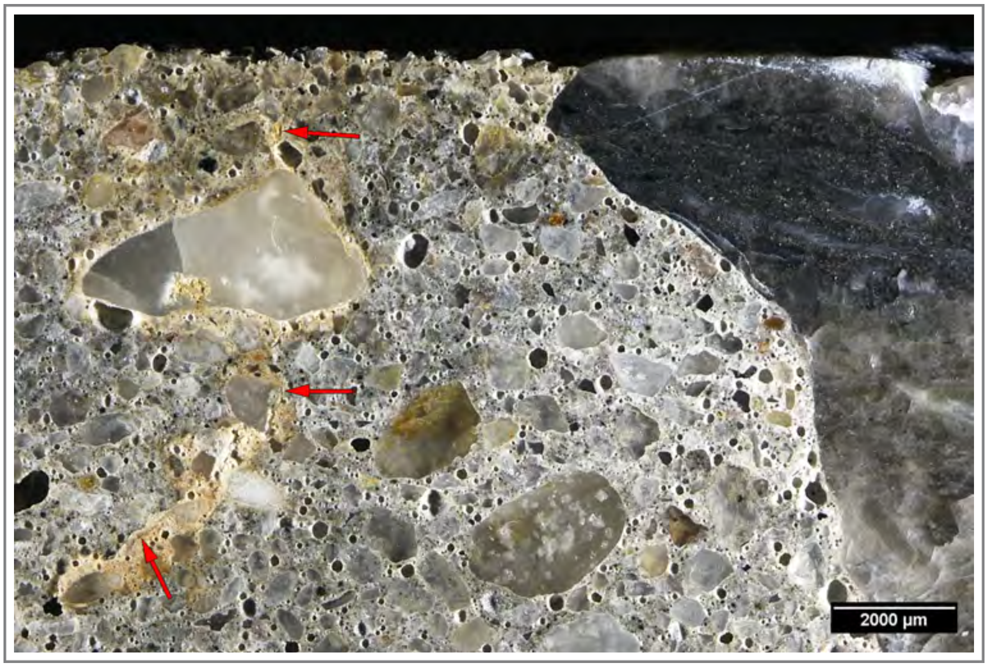
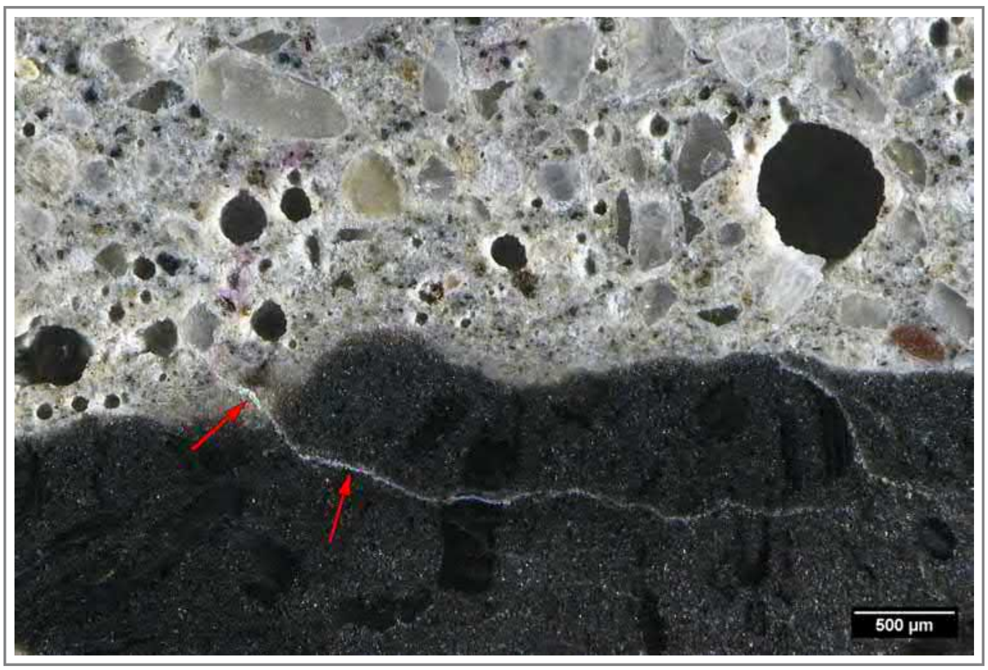


Figure E2. Photograph of the as-received condition of the top surface of the core. Red and yellow arrows indicate exposed coarse and fine aggregate particles, respectively. Scale shows millimeter increments.

Figure E3. Photograph showing the polished surface of the slab prepared from the core. The red and blue dots show the orientation of the saw cuts used to prepare the core. The yellow scale is ~150 mm (6 in.) long; the small and large divisions are in centimeters and inches, respectively.



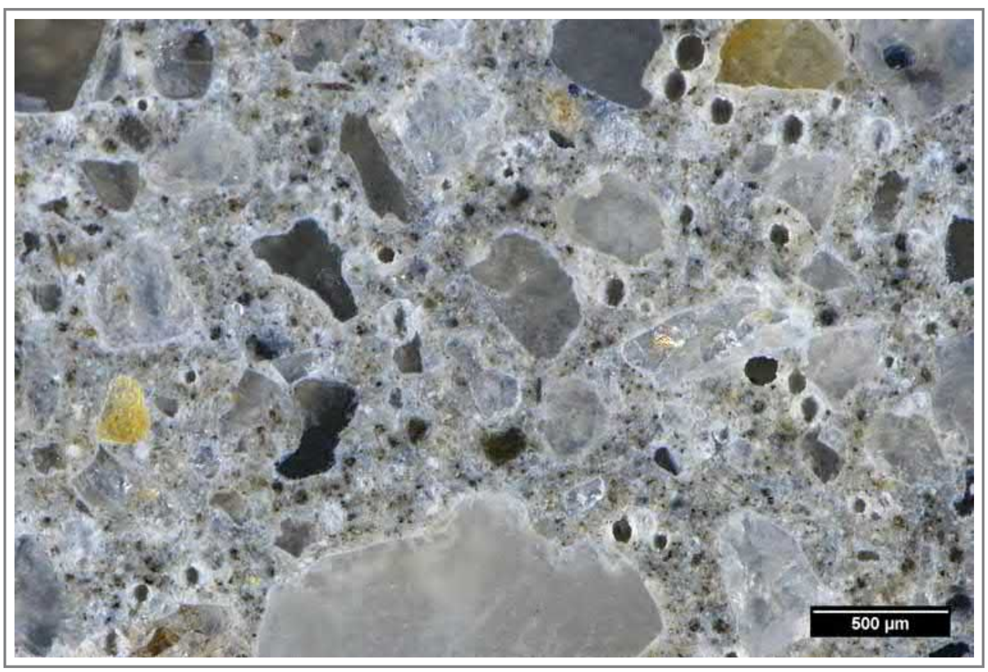
(a)



(b)

Figure E4. Reflected light photomicrographs showing detail of (a) sub-vertical microcracks (red arrows) in the near-surface region of the paste and (b) randomly-oriented and ASR gel-filled microcracks (red arrows) extending outwardly from a reactive coarse aggregate particles.

(a)



(b)

Figure E5. Images showing detail of the paste. (a) Photograph showing paste in the near-surface region of the core. Scale shows millimeter increments. (b) Reflected light photomicrograph showing paste detail in the body of the core.

(a)

(b)

Figure E6. Photographs showing (a) overview and (b) detail of freshly fractured concrete surfaces. Scale in both images shows millimeter increments.

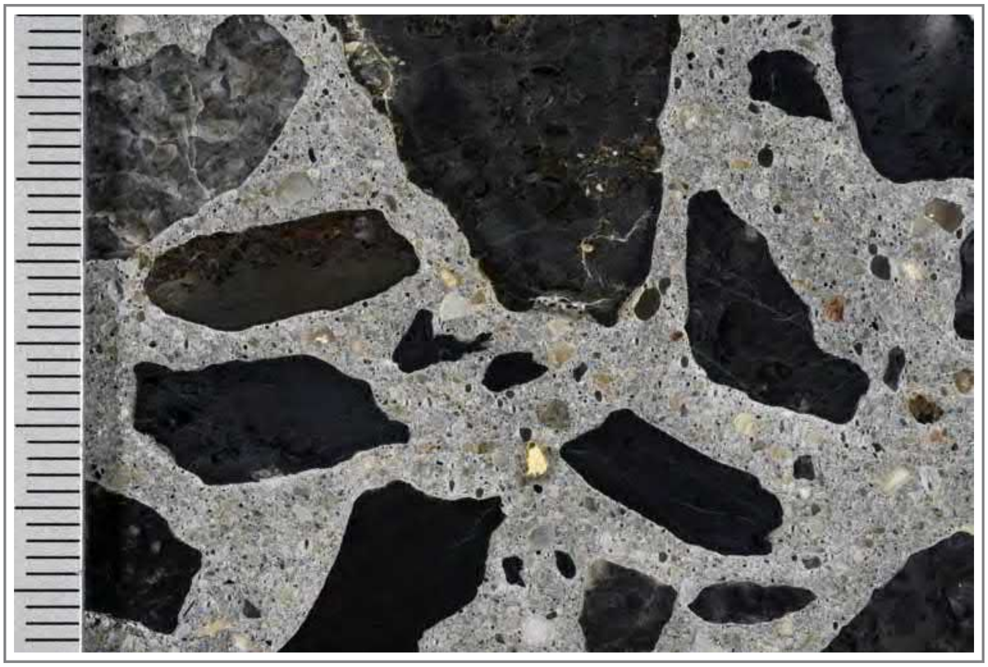


Figure E7. Photograph of the polished surface showing detail of the coarse aggregate. Scale shows millimeter increments.

Figure E8. Reflected light photomicrograph of the polished surface showing low w/cm mortar coatings (red arrows) along a coarse aggregate particle.

Figure E9. Reflected light photomicrograph of the polished surface showing detail of the fine aggregate.

(a)

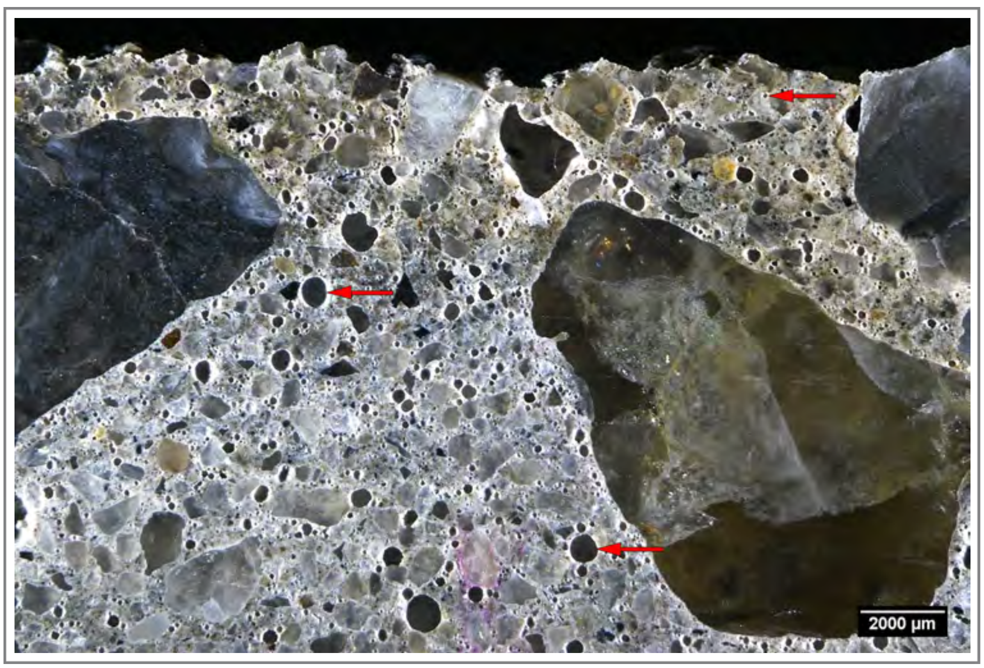
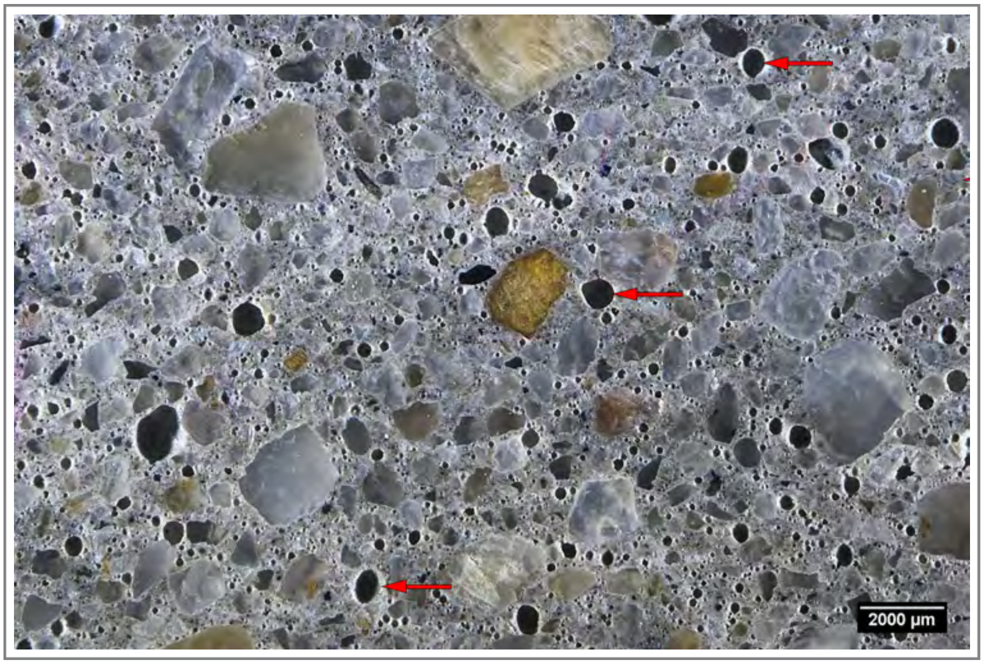
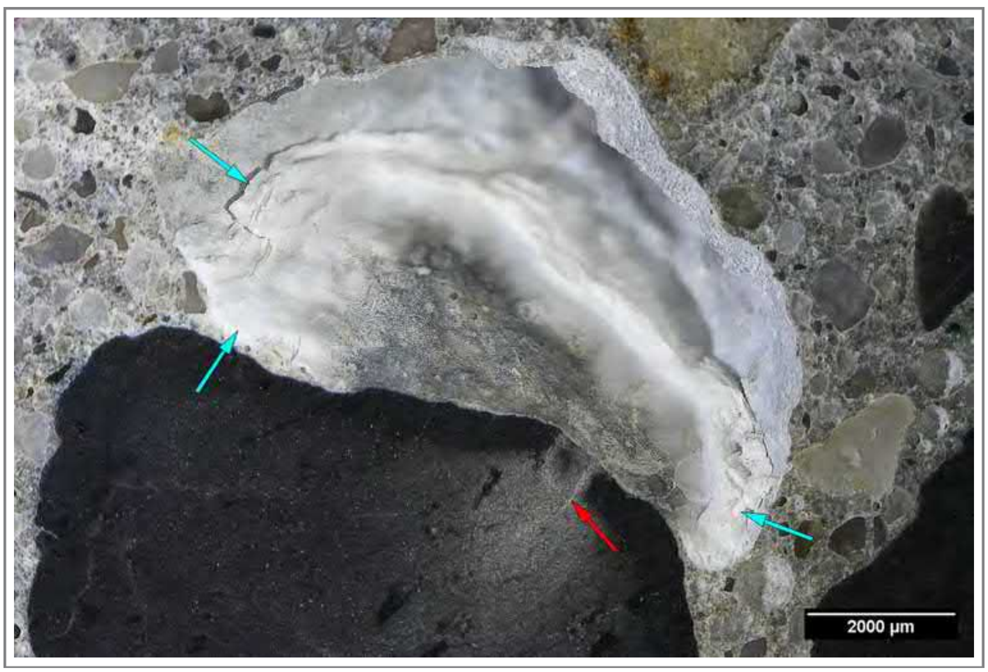


Figure E10. Images showing detail of voids within the core. (a) Reflected light photomicrograph showing detail of voids (red arrows) in the top portion of the core.



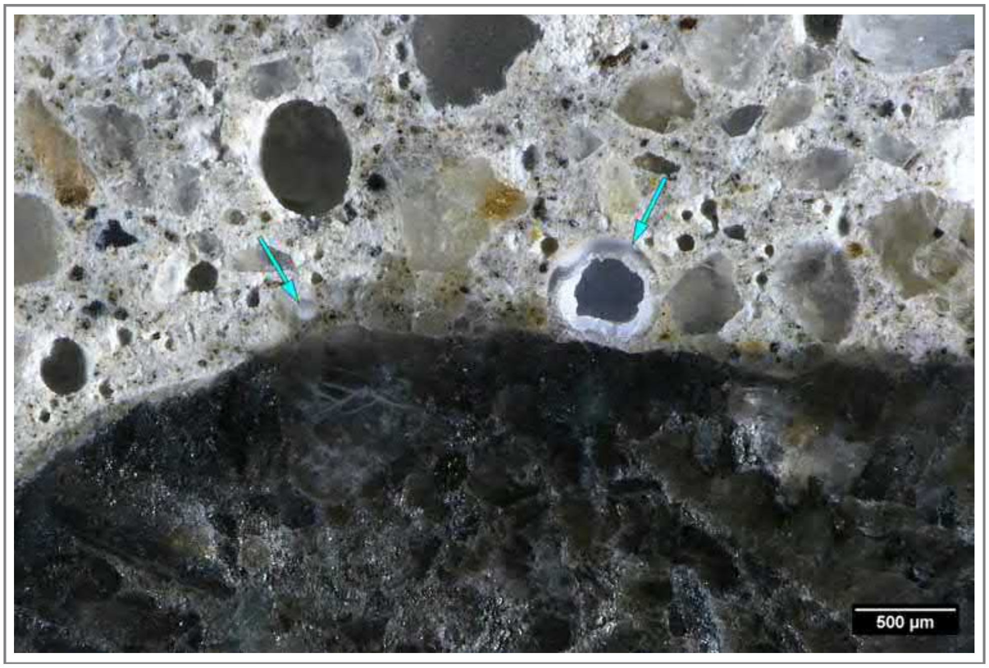
(b)

Figure E10 (cont'd). Images showing detail of voids within the core. (b) Reflected light photomicrograph showing detail of voids (red arrows) in the middle of the core.

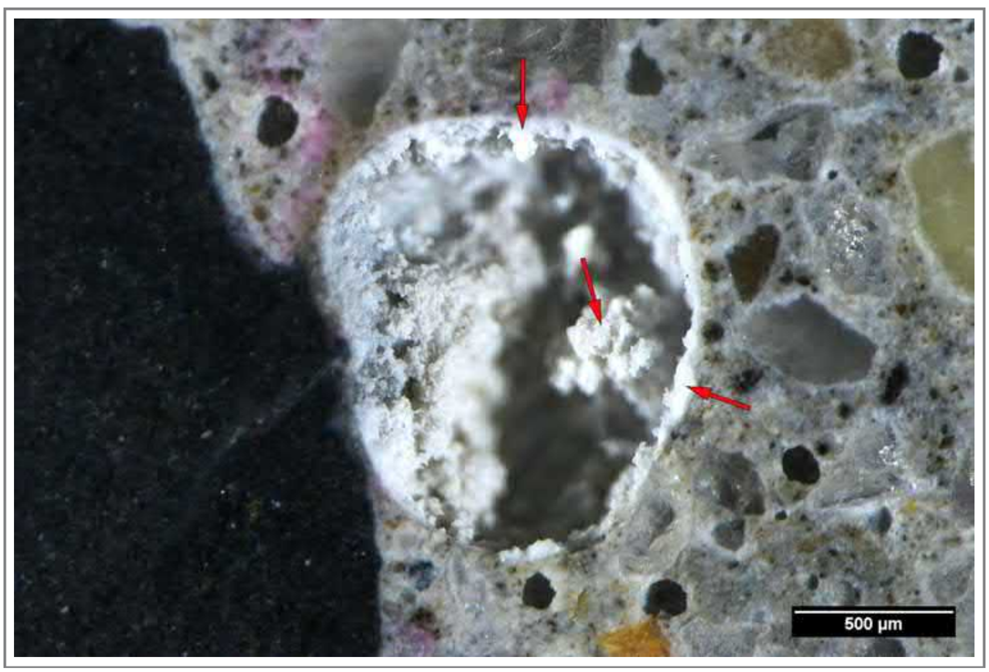


(a)

Figure E11. Images showing detail of secondary deposits in voids. (a) Reflected light photomicrograph of the polished surface showing ASR gel (blue arrows) lining a void. Red arrow indicates ASR gel-filled microcrack in adjacent reactive coarse aggregate particle.



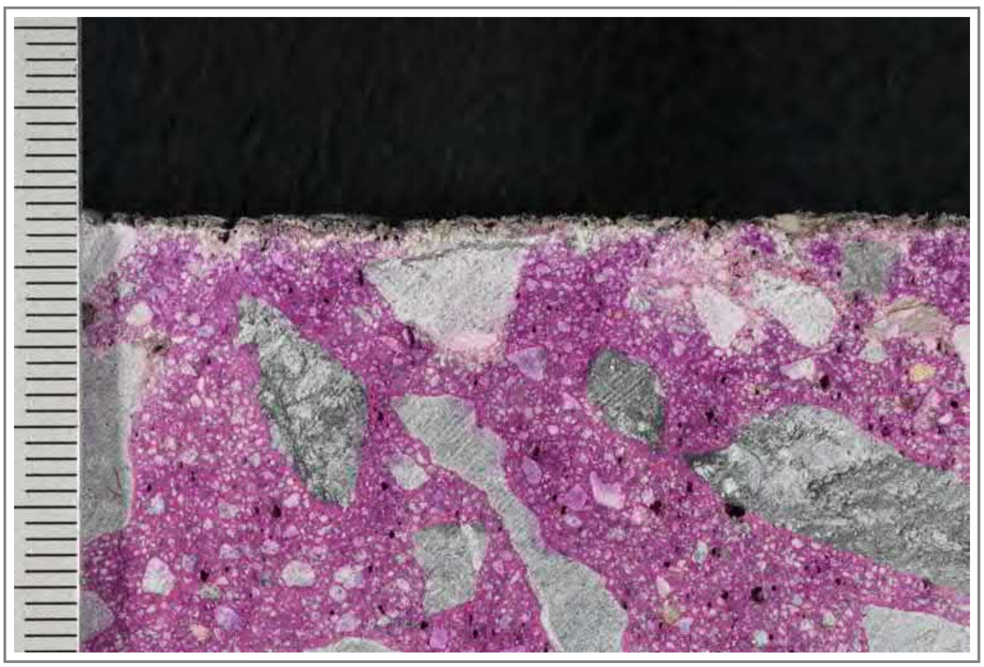
(b)



(c)

Figure E11 (cont'd). Images showing detail of secondary deposits in voids. (b) Reflected light photomicrograph of the polished surface showing ASR gel (blue arrows) lining to filling a couple voids. (c) Reflected light photomicrograph of the polished surface showing ettringite (red arrows) within a void.

(a)



(b)

Figure E12. Photographs showing (a) overview of phenolphthalein-stained cross-sectional surface of the core, and (b) detail of stained surface at the top of the core. The yellow scale in (a) is ~150 mm (6 in.) long; the small and large divisions are in centimeters and inches, respectively. The scale in (b) shows millimeter increments.

PROCEDURES

ASTM C856—Petrographic Examination The petrographic work was done following ASTM C856 [**1**] with sample preparation done at **DRP** in the following manner. After writing the unique **DRP** sample number on the samples near their received labels, the samples were measured and inspected visually and with a hand lens. The orientation of the saw cuts used to prepare the samples were then indicated on the top surface of each core with blue and red dots. The samples were then photographed in their as-received condition.

A slab representing a longitudinal cross section of the core was cut from the central portion of each core using a Raimondini Zipper-105®, a 14-inch diameter water-cooled saw. This produced three (3) longitudinal sections for each core. These sections were rinsed and oven dried in a Gilson® Bench Top laboratory oven at ~40°C (~105°F). After drying, each piece was labelled with the appropriate **DRP** sample number. One piece was set aside for phenolphthalein staining and the other was set aside for thin section preparation.

The central slab was then lapped and polished on a Diamond Pacific® RL-18 Flat Lap machine. This machine employs an 18-inch diameter cast iron plate onto which Diamond Pacific® Magnetic Nova Lap discs with progressively finer grits are fixed. The Nova Lap discs consist of a $^{1}/_{16}$ in. backing of solid rubber containing magnetized iron particles that is coated with a proprietary Nova resin-bond formula embedded with industrial diamonds of specific grit. The slab preparation involved the use of progressively finer wheels to a 3000 grit (~4 μm) final polish following procedures outlined in ASTM C457 [**2**]. An aqueous lubricant is used in the lapping and polishing process. The polished slab was examined visually and with a Nikon® SMZ-25 stereomicroscope with 3-158x magnification capability following to the standard practice set forth in ASTM C856.

Phenolphthalein was applied to a freshly saw-cut surface from each core to assess the extent of carbonation, along with thin section analysis. Phenolphthalein is an organic stain that colors materials with pH of greater than or equal to ~9.5 purple. Portland cement concrete generally has a pH of ~12.5. Carbonation lowers the pH of the paste below 9.5, so areas not stained by phenolphthalein are an indicator of carbonation. The depth of paste not stained by phenolphthalein was measured from each exposed surface.

A petrographic thin section was prepared by cutting a billet from the remaining longitudinal section. Outlines marking the area of the billet were drawn with a marker on the saw-cut surface after visual and microscopical examination of saw-cut and polished surfaces. The billet was labeled with the unique **DRP** number assigned to the sample then fixed to reference glass with a clear ultra-violet light-activated glue. After the glue hardened, the billet was trimmed and then

1 *Standard Practice for Petrographic Examination of Hardened Concrete.* Annual Book of ASTM Standards, Vol. 4.02., ASTM C856-20.

2 *Standard Test Method for Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete*, Annual Book of ASTM Standards, Vol. 4.02, ASTM C457-16.

fixed to a slide with a clear UV activated glue. The billet was then ground and and impregnated with an epoxy that contained fluorescent dye. The impregnated billet was then ground and polished to a thickness of 20-25 µm using a PELCON® automatic thin section machine. The thin section was examined with a Nikon® E-Pol 600 petrographic microscope equipped to provide a 20-1000x magnification range following the standard practice set forth in ASTM C856.

W/C(M) & Capillary Porosity Estimation Estimation of the w/c(m) of the paste is obtained from consideration of the color, texture and luster of the paste observed in reflected light, the hardness (Mohs) of the paste measured using calibrated probes, the packing of cementitious materials and the size and abundance of calcium hydroxide observed in plane and cross-polarized transmitted light, and the green tone of images obtained using fluorescence microscopy. In cases where pervasive carbonation occurs, the original w/cm cannot be estimated quantitatively. Image analysis methods of photomicrographs obtained in transmitted fluorescent light are then used to obtain quantitative measurements of the relative capillary porosity of the paste in such samples.

E. Recommendations

Based on the results of the deck inspections and non-destructive testing, deck replacement is the recommended alternative. The in-depth inspection of the underside of the deck has revealed that there are relatively minor isolated areas of spalling throughout the structure. However, the balance of the deck exhibits cracking, efflorescence and other indicators of leakage. This indicates that the bottom layer of reinforcement is actively corroding, and the majority of the deck area has been compromised and is no longer watertight.